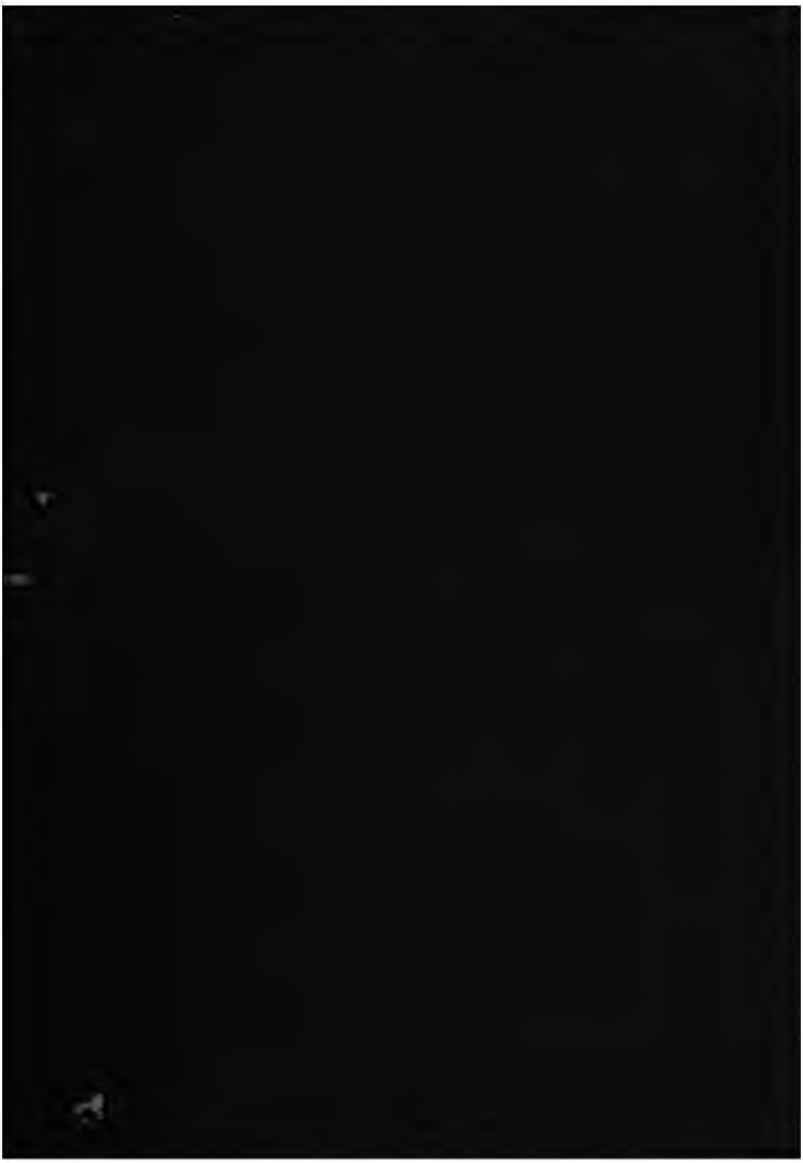
MARTINDALE'S

FIRST LESSONS

IN

NATURAL PHILOSOPHY

PHILADELPHIA:
ELDREDGE & BROTHER
17 North Seventh Street



FIRST LESSONS

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NATURAL PHILOSOPHY

FOR BEGINNERS.

BY

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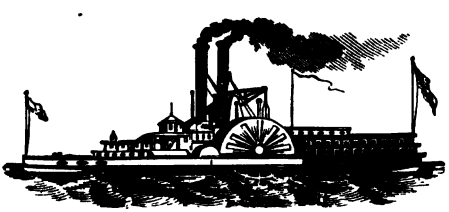

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J. FAGAN & SON,
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PREFACE.

IN preparing this little work, our desire has been to afford both pleasure and profit to those who may read or study its pages.

The most interesting, as well as the most useful things to us, are those with which we meet in every-day life; but we must have some knowledge of these things, ere we can contemplate them with much pleasure, or use them to our greatest profit.

Simple truths in natural science may be learned at an early age; for it requires no more than the ordinary intelligence possessed by boys and girls to understand them. Such facts are not only valuable in themselves, but they are also useful in disciplining the mind by teaching it to observe the many changes constantly going on around us, and to reason and reflect in regard to the same. Habits of observation and reflection thus formed are likely to go with us through life; and they may prove a blessing in a thousand ways; for they will not only add to our comfort and our enjoyment, but they will also produce many a pleasing thought.

We have endeavored to make a book that can be easily understood; but few scientific terms will be found in it, for its language is the language in familiar use; hence, it may serve to interest the fireside circle, and it may be referred to by intelli-

gent boys and girls for answers to the many perplexing questions which are so often presented to their inquiring minds.

Many pupils have not the chance to attend even an Academy or a High School. It is to such that this book is especially adapted, for it is believed to contain as much matter as can be taught with satisfaction and profit in our public or our private schools; but to other pupils, it will prove a valuable introduction to larger and more comprehensive works.

Whenever a drawing would illustrate a fact, and make its application plainer, it has been made; but by far the best illustrations of hundreds of facts, explained in the text, will be found in the world around us, and the attention of both pupil and teacher should always be directed to this reliable and never-ending source.

In presenting these Familiar Lessons in Natural Philosophy to the youth of our country, it is with the earnest hope that it may make them better acquainted with the natural objects surrounding us; that it may lead them to observe the order, the harmony, and the beauty in nature everywhere; and that it may help to turn their thoughts more and more to Him, who is the Creator and Ruler of all things.

J. C. M.

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FIRST LESSONS

IN

NATURAL PHILOSOPHY.

CHAPTER I.

ASTRONOMY.

THE EARTH AND OTHER PLANETS.

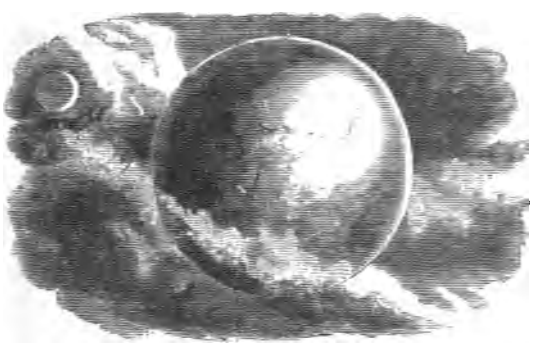


Fig. 1.

WHAT is the shape of the Earth on which we live?

It is round like a ball.

What other names are given to the Earth?

It is called the World or Globe.

What else is it sometimes called?

It is called a Planet.

Are there any other planets?

Yes; some of the stars are called planets.

Is our earth or world a star?

It is a star.

Why do the other stars seem to us different from the earth?

Because they are so far away from us.

What gives light to the planets?

The Sun gives light to the planets.

Of what is the sun the centre?

The sun is the centre of the solar system.

Do the planets remain in one place?

The planets do not remain in one place, but are always moving.

How do the planets move?

They move around the sun.

Are some planets nearer the sun than others?

Yes; some planets are much nearer the sun than others.

Which planet is nearest the sun?

The planet called Mercury.

Which is next to Mercury?

The planet called Venus.

And which is third in distance from the sun?

Our own planet, the Earth.

Are there any planets still farther from the sun?

Yes; Mars, Jupiter, Saturn, Uranus, and Neptune, and many smaller planets.

How does each planet move?

It moves in its own track or orbit around the sun, as is represented in Fig. 2.

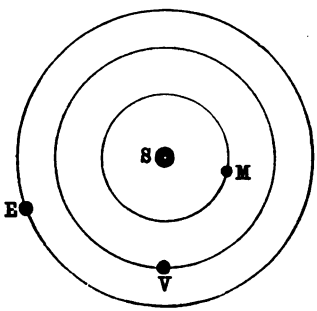


Fig 2.

Does the earth always move in the same orbit around the sun?

Yes; the earth moves in the same orbit around the sun, year after year.

How long does it take the earth to move around the sun?

365 days, 5 hours and 49 minutes, or one year.

What makes a year to us?

A year to us is the time required by the earth to move around the sun.

If the earth is in a certain place at noon, on New Year's day, when will it be in that place again?

5 hours and 49 minutes after noon on New Year's day of the next year.

What, then, does the earth do every year?

The earth moves around the sun and comes back to the place whence it started, once every year.

Has the earth any other motion than the one around the sun?

It has; it turns over and over.

Does the earth stay in one place as it turns over and over?

It does not; it moves on in its track around the sun.

How many times does it turn over while going around the sun?

Three hundred and sixty-five times.

How many times, then, does it turn over in one year?

The earth turns over three hundred and sixty-five times in a year.

What is the time which it takes to turn over once called?

It is called a day.

How many days in a year?

There are three hundred and sixty-five days in a year.

What two motions, then, has the earth?

It turns over and over, and at the same time it moves around the sun.

What change is produced on the earth by its moving around the sun?

The change of Seasons.

Will you name the seasons?

Winter, Spring, Summer, and Autumn.

Do they follow each other in regular order?

They do; Spring follows Winter, Summer follows Spring, Autumn follows Summer, Winter follows Autumn, and Spring follows Winter again.

How often have we these seasons?

As often as the earth moves around the sun, which is once a year.

What change is produced on the earth by its turning over?

The change of day and night.

Where is it day?

It is day on that part of the earth which is turned towards the sun.

Where is it night?

It is night on that part of the earth which is turned away from the sun.

How often do we have the change from day to night?

As often as the earth turns over, which is once in twenty-four hours.

What is a day?

A day is the time from sunrise till sunrise again, from sunset till sunset again, from noon till noon again, or from midnight till midnight again.

What does a day include?

It includes the night-time as well as the day-time, of the twenty-four hours.

When it is day-time on one part of the earth, what is it on the opposite part?

It is night-time on the opposite part.

When it is morning to us, what is it to people living on the opposite side of the earth?

When it is morning to us, it is evening to them; when it is day-time to us, it is night-time to them; and when it is noon to us, it is midnight to them.

On how much of the earth is it always day?

It is day on one-half of the earth, while on the other half it is night.

The sun seems to move around the earth; does it really do so?

No; it does not move around the earth.

Does the *earth* move?

Yes; it turns over once every day.

Why does it not seem to us to be moving?

Because we move along with it. If we are on a railroad car, the trees and houses along the road appear to move, and the car to stand still; but the car really moves, while the trees and houses stand still.

In what direction does the earth turn on its axis?

The earth turns from west to east.

Where do the sun, moon, and stars rise?

The sun, moon, and stars rise in the east.

The teacher may, by means of a ball or small globe, readily make these things so plain that they can be understood even by small children.

When is it sunrise to us?

When the part of the earth on which we are, first comes into the sun's rays.

When is it sunset to us?

When the part of the earth on which we are, moves out of the sun's rays.

The Moon.

We have been told that the earth moves around the sun; does any planet move around the earth?

Yes; one planet moves around the earth.

What is that planet called?
It is called the Moon.

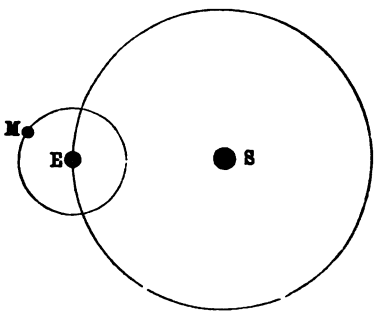


Fig. 3.

How often does the moon move around the earth?
Once in 27 d. 7 h. 43 min.

How long is the time from new moon to new moon again?
It is 29 d. 12 h. 44 min.

How often do we have new moon?
Once every 29 d. 12 h. 44 min.

What is the period from one new moon to another called?
It is called a Lunar month.

Are the lunar months all of the same length?
Yes; they are all of the same length.

Is there any other kind of month?
Yes; the Calendar month, as it stands in almanacs.

How many calendar months in a year?
There are twelve calendar months in a year.

Are the calendar months all of the same length?

No; some are thirty-one days long, some thirty days long, and one only twenty-eight days long.

When can we see the moon and stars best?

We can see them best when it is night.

From what do the moon and the other planets get their light?

They get their light from the sun.

What do they do with this light?

They reflect it.

How do we see them?

We see them by the light which they reflect.

Why cannot we see the moon and stars in the day-time?

Because the bright light of the sun hides their light.

Are there stars in every direction around the earth?

There are stars in every direction around the earth.

How do we know this?

Because stars may be seen from every part of the earth, when it is night.

Stars are in every direction around the earth, just as we may imagine the apples to be in every direction around a boy who has climbed into a tree full of that fruit.

What planet moves around the earth?

The moon moves around the earth.

Upon what part of the moon does the sun shine?

It shines upon the part towards the sun.

What does the moon do with the light which it receives from the sun?

The moon reflects the light received from the sun.

What is this reflected light called?

It is called moonlight when reflected from the moon.

Is that part of the moon on which the sun shines always towards the earth?

It is not always towards the earth.

When all of the moon on which the sun shines is towards the earth, how does the moon appear?

The moon appears to be round, and the whole of it seems to shine.

What is the moon then called?

It is called the Full Moon.

When no part of the moon on which the sun shines is towards the earth, how does the moon appear?

We do not see the moon at all, and we say there is no moon.

When a small part of the moon on which the sun shines is first turned towards the earth, what is it called?

It is called the New Moon.

Does the lighted part of the moon grow?

It seems to grow larger and larger, until the whole of the moon is lighted.

What is it then called?

It is then called the Full Moon.

What then takes place?

It seems to grow smaller and smaller, until the whole of the lighted part is gone.

Just before the last part is gone, what is it called?

It is called the Old Moon.

How long is it from one full moon to another full moon?

It is a lunar month.

How many full moons are there in a year?

There are thirteen full moons in a year.

Is the sun much larger than the moon?

The sun is many thousand times larger than the moon.

Why does the moon appear nearly as large as the sun?

Because it is so much nearer to us.

How far is the moon from the earth?

The moon is nearly 240,000 miles from the earth.

How far is the sun from the earth?

The sun is nearly 92,000,000 miles from the earth.

How long does it take the light of the sun to reach the earth?

It takes about eight minutes; therefore, the light of the sun must travel about twelve millions of miles in a minute, or two hundred thousand miles in a second of time. At this rate, the light would come from the moon to the earth in a little more than one second of time. It would take no longer for it to come than it does for the pulse to beat once, or the clock to make one tick.

Eclipses.

How do we know that the earth is round, like a ball?

We know that the earth is round like a ball, because its shadow is similar to the shadow of a ball.

How else do we know that the earth is round?

We also know that the earth is round, because we can circumnavigate or sail around it.

Where can we see the shadow of the earth?

We can see the shadow on the moon, when the moon is eclipsed.

What is the shadow on the moon like?

It is round, like the shadow of a ball.

When the Earth comes between the sun and the moon, where does the shadow of the earth fall?

The shadow of the earth falls on the moon, as is represented in Fig. 4.

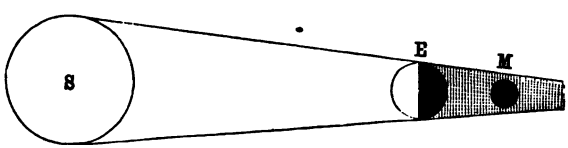


Fig. 4.

What is this shadow on the moon called?

It is called an Eclipse of the moon.

How do we know that the moon is round?

We know that the moon is round, because its shadow is similar to the shadow of the earth.

When is the moon eclipsed?

When it comes into the earth's shadow.

When the moon comes fully into the earth's shadow, what is it called?

It is called a total eclipse of the moon.

When it comes partly into the earth's shadow, what is it called?

It is called a partial eclipse of the moon.

When the moon comes between the sun and the earth, where does the shadow of the moon fall?

The shadow of the moon falls on the earth, as is represented in Fig. 5.

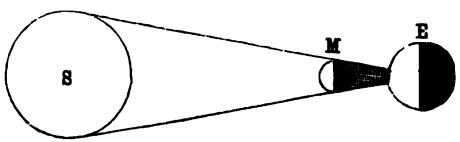


Fig. 5.

What does this produce?

It produces an eclipse of the sun.

When the moon is between the sun and the earth, can we see the sun?

No; we cannot see the sun, because the moon prevents the rays of the sun from coming to us.

When the moon prevents the sun's rays from falling on us, what is it called?

It is called an eclipse of the sun.

When the moon prevents *all* the sun's rays from falling on us, what is it called?

It is called a total eclipse of the sun.

When the moon prevents only a part of the sun's rays from falling on us, what is it called?

It is called a partial eclipse of the sun.

When will the *sun* be eclipsed?

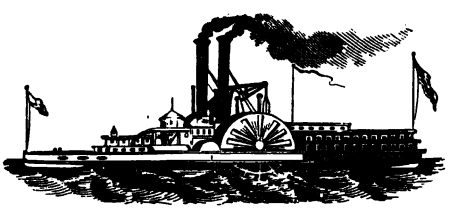
Whenever the moon comes between the sun and the earth.

When will the *moon* be eclipsed?

Whenever the earth comes between the sun and the moon.

Who made the sun, the moon, and the stars?

God, the creator of all things, made the sun, the moon, and the stars. He placed them in the heavens, where they remain in obedience to His will. He made the bright rays from the sun to light up the day, and give beauty to the world; but the feebler rays of the moon and the stars are seen best at night, when the sun is hid.



CHAPTER II.

LIGHT.

COLOR.

IN what way is the sun useful to us?

It gives heat, which makes us warm, and it gives light, so that we can see.

Is it useful in any other way?

It gives light and warmth to all animals as well as to all plants.

What make the flowers and leaves so beautiful?

The light and heat from the sun make them beautiful.

What do the light and heat from the sun ripen?

They ripen the apples, cherries, and other fruits; also, the wheat, corn, and other grains, and make them fit for food.

When it is night-time or dark, can we distinguish objects?

No; because all things are then without color, and they cannot be seen.

As it grows light in the morning, what takes place?

At first, we see the objects around us faintly; but as it grows lighter, we see them more distinctly.

Do they all show the same color in the light?
They do not; they show different colors.

What enables us to see the color of different things?
Light enables us to see the color of everything.

What kinds of light have we?
We have the light of the sun, moon, and stars; also, the light from the burning of any substance.

Does the light show many colors?
It does show many colors or shades of color.

How may some colors be made?
They may be made by mixing other colors together.

How can we make a purple color?
By mixing a red and a blue color together.

How can a green color be made?
By mixing a blue and a yellow color together.

How can an orange color be made?
By mixing a red and a yellow color together.

How does the light come from the sun?
It comes in rays or straight lines.

What may be done with a ray of light?
It may be separated into different colors.

Into how many colors may a ray of light be separated?
Into *seven* colors, like the colors of the rainbow.

What names are given to these colors?
Red, orange, yellow, green, blue, indigo, violet.

How may these colors be separated?
By a prism, or three-sided piece of glass.

How may this be done?
If a sunbeam, shining through a hole in the win-

dow-shutter of a dark room, should fall upon a prism, it will be broken up as it passes through the prism, and be shown on the opposite wall, in the seven rainbow colors.

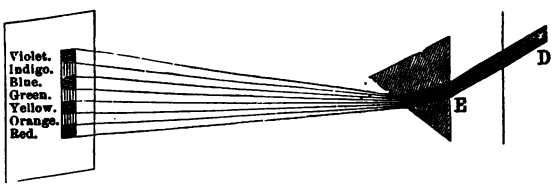


Fig. 6.

In Fig. 6, D is a sunbeam passing through a shutter. When it passes through the prism, at E, it is separated into the seven rainbow colors, as is shown on the opposite wall.

In what order will these colors appear?

They will always appear one above the other, in the order named.

How may this order be remembered?

By the word Roy-g-biv, made from their initial letters, beginning at the bottom.

From what are the colors of the rainbow made?

From the rays of light coming from the sun.

When is a rainbow seen?

A rainbow is seen when the sun shines through the drops of water as they fall through the air.

How do the drops of water help to make a rainbow?

The drops of water act like little prisms, and separate the rays of light passing through them into the colors of the rainbow.

What two things, then, are needed to make a rainbow?

A shower of water, and a bright sunshine.

In what part of the sky does the rainbow appear?

In the part opposite to that in which the sun is, at the time of the shower.

How does the rainbow appear?

It appears like a great arch, spanning the sky, and its splendid bright colors are very beautiful.

What may we remember in reference to the rainbow?

We may remember that God set his "bow" in the cloud, as a token that the world should no more be destroyed by a flood of waters.

Where else may we see a variety of colors?

In the soap-bubble.

Why are these colors constantly changing?

Because the walls of the bubble are constantly growing thinner, and different colors are, therefore, reflected from them.

Why do the walls of the soap-bubble grow thinner?

Because the water runs to the bottom of the bubble until its top becomes so thin as to burst.

Can we tell the color of any object by touching it?

No; we must see it in order to tell its color.

How do we know this?

If there are two coats, one blue and the other black, we cannot tell which is the blue one or which is the black one, by feeling them.

What is necessary in order to see the colors?

Light is necessary; because all colors come from the rays of light.

Can we see the different colors in the ray itself?

We cannot; because God has so blended them together that they cannot be seen by us.

When most of the rays of light pass through a substance, what is said of it?

The substance is said to be *transparent.*

Name some transparent substances.

Glass, ice, diamonds, air, and clear water.

When only a few rays of light pass through a substance, what is said of it?

The substance is said to be *translucent.*

Name some translucent substances.

Flint, isinglass, scraped-horn, and china-ware.

When no rays of light pass through a substance, what is said of it?

The substance is said to be *opaque.*

Name some opaque substances.

Wood, iron, coal, and granite.

Can we see through a glass window?

Yes; because the glass is transparent, and the light passes through it.

Can we see through a looking-glass?

No; because the back of the looking-glass is covered with quicksilver, which prevents the rays of light from passing through it.

What becomes of the light falling on the looking-glass?

It is thrown back from the glass.

What is this called?

It is called *reflection.*

What objects are good reflectors of light?

Those having smooth and polished surfaces; such as tin, silver, gold, and quicksilver.

What objects are poor reflectors of light?

Those having dull, uneven surfaces; such as iron, wood, cloth, leather, and calico.

Of what is every ray of sunlight composed?

It is composed of the seven colors of the rainbow.

What does a looking-glass do with these colors?

A looking-glass throws them all back from its surface.

What does a glass window do with these colors?

A glass window permits all these colors to pass through it.

What do opaque substances do with these colors?

They throw back or reflect some of them.

Do they all reflect the same color?

No; some reflect one color, and some another color.

What color does the grass reflect?

It reflects the green color; therefore, the grass is green.

What does the grass do with the other colors?

It absorbs or hides them in itself.

How do we know the color of anything?

We know it by the color which it reflects.

Why is the rose red?

Because it reflects the red color, and absorbs or hides the other colors in itself.

When anything *absorbs* all the colors of a ray of light, what color is it?

It is black.

When it *reflects* all the colors of light, what color is it?

It is white.

Why are the letters on this page black?

Because they absorb all the colors of light, and reflect none.

Why is the paper white?

Because it reflects all the colors of light, and absorbs none.

Why are all things black in the dark?

Because there are no rays of light falling on them; hence, there is no color for them to reflect.

Does an object reflect its color in every direction?

It does reflect its color in every direction.

How do we know this?

Because thousands of persons, in different directions from the same object, can see it at the same time.

How are the rays of color reflected from an object?

They are reflected in straight lines.

Where must a person be so as to see an object?

He must be in a position so that there is nothing to prevent the rays of light passing in a straight line from the object to his eyes.

What color does a red ribbon reflect?

It reflects a red color.

Why are some red ribbons of a brighter red than others?

When they reflect a great many red rays, they are of a bright red color; but when they reflect only a few red rays, they are of a dull red color.

Upon what does the brightness or dullness of a color depend?

It depends upon the number of rays of that color reflected.

What variety does this produce?

It produces a great variety in the shades and tints of color.

Where may many of these shades and tints be seen?

In the pretty flowers that grow in the woods, fields, and gardens; in the beautiful tints of the leaves in autumn; and in the plumage of the birds that visit us every spring, and cheer us with their songs.

What may these things teach us?

They may teach us the goodness of God, in giving us a world so full of beauty; and we should feel ever thankful to Him for the great pleasure that we have in seeing them.

Why cannot we see the light of a lamp or candle distinctly, in the day-time?

Because the strong rays from the sun hide the more feeble rays from the lamp.

Why cannot we see the stars in the day-time?

Because the bright light from the sun hides their more feeble light.

When can we see the glow-worms or fire-flies best?

At night, when it is dark; because, at other times, the light of the sun hides their feeble light.

Where may we see them at night?

Flying about in all directions, looking like bits of fire moving in the air.

Does a looking-glass reflect all the colors of light falling upon it?

It does; hence, the ray of light is not changed.

When the object is of a blue color, why is blue only reflected?

Because it is the only color falling upon the glass, and there is no other color to reflect.

Is the color of any object changed by falling upon a looking-glass?

No; the color of every object is reflected from a looking-glass without change.

Do other objects generally reflect the colors falling upon them?

They do not; they absorb or hide the color of all other objects, and reflect only their own color.

If every object was a good reflector of color, like a looking-glass, what would result?

Then every object would reflect the color of every other object around it, and there would be an endless confusion of colors.

What objects reflect the most light?

Those of a white or light color.

What objects reflect the least light?

Those of a darker color; and the nearer the color approaches to black, the less light it reflects.

Why is it darker when the sky is covered by dark-colored, than by light-colored, clouds?

Because the dark-colored clouds reflect less light, than the light-colored clouds do.

What advantage do we derive from the green color of the grass and the leaves?

They reflect a soft, pleasant light, which does not dazzle or hurt our eyes.

How would it be if those objects were white?

They would dazzle us by the amount of light reflected.

If we wish to make a room light, of what color should the walls be?

They should be white; and when papered, it should be with light-colored paper.

Why does dark-colored paper darken a room?

Because it absorbs some of the rays of light which come in at the windows; hence, there is less light in the room. Dark-colored carpets, or dark furniture, darken the room for the same reason.

Does the light from a burning body differ from sun-light?

Yes; it differs in intensity, in color, and in many other ways.

What effect does the lamp-light have upon the color of some substances?

It changes their color.

Where may we find an example of this?

In trying to match the colors of thread or silk at night.

Why is the color different by lamp-light from what it is by daylight?

Because the yellow color of the lamp's rays acts upon the color of the silk, forming a third color. Blue silk becomes green by lamp-light, and red silk becomes orange.

Are all persons able to distinguish one color from another?

No; some are color-blind. To such persons all colors appear to be alike.

What curious instances of color-blindness may be mentioned?

Dr. Mitchell tells of an officer who bought a blue coat and a red waistcoat, thinking them to be of the same color. He also tells of a tailor who patched a black waistcoat with a piece of crimson; and of another, who put a red collar on a blue coat. Dr. Dalton lost a piece of red sealing-wax in the grass, and he could not find it because it and the grass seemed of the same color to him.

Refraction of Light.

How do the rays of light from the sun come to us?

They come to us in straight lines.

When the rays of light pass from one substance to another more dense, what takes place?

They are bent or turned from a straight course.

What is said of these bent rays?

They are said to be *refracted.*

What is meant by refraction?

Bending a ray of light, as it passes from one substance to another of different density; as from air to water, or from water to air.

Where may we see an example of refraction?

Fig. 7.

In the rays of light from a rod which has one end in the water.

Why does the rod appear to be bent?

Because light coming from the part of the rod under the water, is refracted or bent at the surface of the water, while the light from the part above the

surface, comes in straight lines to the eye; hence, the rod appears to be bent at the surface, as is represented in Fig. 7.

How does a pole appear when one end is placed in the water?

It appears to be bent where it meets the surface of the water.

How does the part of the rod under water appear?

The part under the water appears to be raised up, as may be seen in Fig. 7.

How does the bottom of a pond or stream of water appear?

It appears to be raised up, and the water does not seem so deep as it really is.

Why is this the case?

Because the light from the bottom of the pond is refracted or bent at the surface of the water; hence, the bottom appears to be raised up.

How much does the bottom of a pond or stream of water seem to be raised up?

About one-third of the depth of the water.

If the water is really six feet deep, how deep does it appear?

It appears to be only four feet deep.

What has frequently happened from not knowing this fact?

People have been drowned from getting into water deeper than it appeared to be.

Do the fish and other things floating in the water appear to be raised up?

Yes; like the bottom of the stream, they also appear to be only two-thirds as far from the surface as they really are.

If we wish to spear the fish, what must we do?

We must aim below the place where they seem to be, or we must strike perpendicularly at them.

Reflection of Light.

When a ball is thrown against a wall, what is the path through which it goes called?

The line of incidence.

When the ball bounds back, what is its path called?

The line of reflection.

What is the angle at which a ball strikes the wall called?

The angle of incidence.

What is the angle at which the ball rebounds called?

The angle of reflection.

When a ray of light falls upon a looking-glass, what is the path through which it goes called?

The line of incidence.

When the ray is reflected, what is its path called?

The line of reflection.

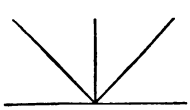


Fig. 8.

The *angle of incidence* is the angle between a perpendicular and the line of incidence; and the *angle of reflection* is the angle between the perpendicular and the line of reflection. The two angles are always equal to each other, as is represented in Fig. 8.

When a ray of light strikes a looking-glass obliquely or slantingly, what is done with it?

The ray is reflected as obliquely from the glass as it strikes or falls upon it.

Why is the reflection of the sun in a pond of water seen near the edge at noon?

Because the angle of reflection is equal to the angle of incidence; and the observer must be nearly over the place where the rays strike, so that, when reflected, they may meet his eye.

Where is the reflection seen in the morning or in the evening?

It is seen nearer the middle of the pond; because the sun's rays then fall more obliquely on the pond, and are reflected more obliquely to the eye.

When an opaque object is placed between a candle and a wall, why will there be a shadow?

Because the opaque object prevents the rays of light from falling on the wall.

Why will the shadow be larger, the nearer the object is to the candle?

Because the rays of light diverge, in every direction from the candle, in straight lines, and the nearer the object, the more rays will it intercept, as is represented in Fig. 9.

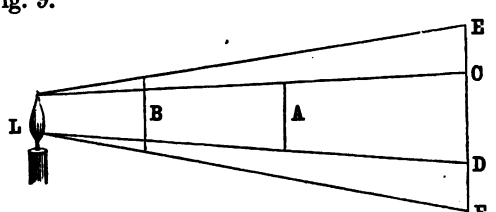


Fig. 9.

In Fig. 9, let L represent the flame of a candle. When the object is placed at A, the shadow on the wall will extend from C to D; but when the object is moved nearer, as at B, the shadow will extend from E to F.

Why does an object seem to be smaller, the farther it is from us?

Because the angle at which the light from it strikes the eye, is less when at a distance, than when near to the eye.

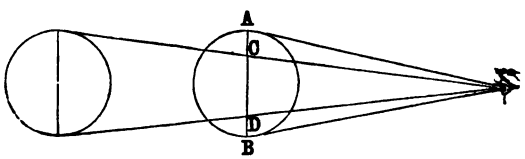


Fig. 10.

In Fig. 10, the diameter of the near circle is from A to B; but the diameter of the more distant circle, although just as large, seems only to be from C to D.

Why does an object grow more dim the farther it is from us?

Because the rays of light from it spread out in every direction; and fewer rays enter the eye when it is at a distance than when it is near by.

What is the use of the telescope?

It is used to view distant objects.

Why can we see a distant object more distinctly with a telescope, than without one?

Because the telescope enlarges the image of the object, and it also collects more light from that object than is collected by the unaided eye; thus, making the image distinctly visible.

What class of objects do we view with a telescope?

We view the heavenly bodies; the sun, moon, and stars.

What is a spy-glass?

It is a glass mostly used to view distant objects on the earth.

Is the spy-glass like the telescope?

The spy-glass is much like the telescope, only it is smaller.

When looking through a spy-glass, how do objects appear?

They seem to be brought nearer to us, and they appear larger.

By whom are spy-glasses much used?

Spy-glasses are much used by persons on board of vessels, while at sea.

What instruments have we for magnifying small objects?

We have magnifying glasses and microscopes.

What are magnifying glasses?

They are single glasses or lenses, used for magnifying small objects.

By whom are magnifying glasses used?

They are used by jewellers, watchmakers, engravers, and others who examine small objects.

What are microscopes?

They are instruments used for examining very small objects.

How does a drop of rain-water or vinegar appear under the microscope?

It appears to be full of strange-looking creatures, which are always in motion.

How do the smallest insects appear?

They appear to be as perfectly formed as the larger ones which are seen with the naked eye.

What may be seen with a microscope?

Thousands of things too small to be seen by us unless they are magnified.

What kind of spectacles do near-sighted people use?

Near-sighted people use glasses, thickest at the edge and thinnest at the centre.

What kind of spectacles do we use as we grow old?

As we grow old we use glasses, thinnest at the edge and thickest at the centre.

Of what use are spectacles?

When the vision is defective, spectacles enable us to see objects more clearly.

How should spectacles be made?

They should be so made as to render objects distinct, but neither to magnify nor diminish them.

As people grow old, how do their eyes change?

Their eyes change so that they see objects at a distance better than those which are nearer, hence, in reading they hold a book farther from the eye.

The Eye.

What is that part of the eye called, which is blue, gray, or brown, in different persons?

It is called the *iris*.

Fig. 11.

What is the pupil of the eye?

The pupil is the black spot or hole in the centre of the iris.

What is the use of the pupil?

The pupil is the window of the eye, and the rays of light which enter the eye must pass through it.

What power has the iris over the pupil?

The iris has the power of making the pupil larger or smaller, according to the amount of light which it receives.

How does a bright light affect the iris?

It causes the iris to contract, so that the pupil becomes smaller.

How does a faint light affect the iris?

It causes the iris to dilate, so that the pupil becomes larger.

Of what advantage is the iris to the eye?

The iris acts like a sentinel to protect the eye from any sudden light.

How does a sudden light affect the eye?

A sudden light causes pain to the eye.

Of what shape is the pupil of the eye?

In man, the pupil of the eye is circular.

What is the size of the pupil of the eye?

The pupil varies from the one-twentieth to the one-third of an inch in diameter, depending upon the brightness of the light entering the eye.

How else are our eyes protected from any sudden light?

By means of our eyelids, which may be closed, and thus shut out all the light.

When we pass from a well-lighted room into the open air, at night, why does it seem darker at first than it does afterwards?

Because the pupil is contracted at first; but it soon dilates, and allows more rays of light to pass into the eye, so that the night seems less dark.

Why does the pupil become larger in the twilight?

So that more rays of light may enter the eye, whereby objects may be more distinctly seen.

Why can an owl or a bat see at night?

Because the pupil of the eye in them is quite large, and admits much light.

Why do they stay in dark places through the day?

Because the bright light of day hurts their eyes.

May the image of an object be retained in the eye after the eyelids are closed?

It may for a very short time, as any one can prove by first looking at some bright object, and then closing the eyelids.

Why does a burning coal moved rapidly around, seem like a circle of fire?

Because the light from it is retained a short time by the eye, thus seeming to form a complete circle.

Why cannot we count the posts in a fence, when riding rapidly in a car?

Because the light from each post falls in such quick succession upon the eye, that it cannot distinguish one post from another.

Can objects be seen distinctly when placed near the eye?

No; when objects are within six inches of the eye they cannot be seen distinctly.

Can objects be seen when at a great distance from the eye?

Yes; objects may be seen even when millions of miles away from us; thus, the sun is seen although ninety-five millions of miles from the earth, and some

of the stars which we behold in the heavens, are still farther away than the sun.

Of what use is the eye to us?

The eye gives us ideas of the size, the shape, the color, the place, the distance, and the movements of things around us, so that we can use them the better to promote our comfort and our happiness.

What may we remember about the light?

And God said, "Let there be light;" and there was light. Thus the day was separated from the night, and the sun was made to send forth his silvery rays upon hill and valley, field and forest, causing the rarest buds and most beautiful blossoms to come forth from the lifeless earth, although no eye, save the All-Seeing One, was there to behold them!

CHAPTER III.

HEAT.

SOURCES OF HEAT.

WHAT is heat?

Heat is that agent which causes the feeling of warmth?

Can heat be seen?

No; heat cannot be seen, it can only be felt.

When we touch a substance hotter than we are, what takes place?

A part of the heat from that substance comes to us and causes a feeling of warmth.

When we touch a substance colder than we are, what takes place?

A part of the heat from us goes to that substance, and we experience a feeling of cold.

Does the amount of heat in any substance vary?

Yes; water may be heated until it is scalding hot, or the heat may be taken from it until it is frozen into ice.

What causes a substance to become cold?

Taking away heat from a substance causes it to become cold.

Then what is *cold?*

Cold is only the absence or want of heat.

When we pass from a very hot room to one moderately warm, how do we feel?

We experience a feeling of cold.

When we pass from a very cold room to one moderately warm, how do we feel?

We have a feeling of warmth, although the room is no warmer than in the first instance.

How else can we prove that we judge of heat and cold by our feelings?

If one hand be held in quite warm water, and the other in quite cold water, for a few moments, and then both hands be plunged into tepid water, the tepid water will feel cold to the hand that was in the warm water, and warm to the hand that was in the cold water.

Is there anything without heat?

No; the coldest substance known still contains some heat.

How many kinds of heat are there?

There are two kinds of heat.

What are the two kinds of heat?

Heat accompanied by light, as the heat from the sun, or a lamp; and heat without light, as the heat from boiling water.

From what source does heat mostly come?

Heat mostly comes from the sun, which is also the source of light.

What is said of the heat and light from the sun?

Heat and light from the sun come together in the sunbeam.

From what other source is heat obtained?

Heat is obtained from the burning of any substance.

What else does the burning of any substance produce?

It often produces light.

Can the light and heat from the sun easily be separated?

They cannot easily be separated.

What does a glass window do with the light and heat of the sunbeam?

It permits both the light and the heat to pass into the room, so that we can see the one and feel the other.

Are the light and heat from a fire united, as they are in the sunbeam?

They are not; but they seem to be separated from each other.

What does a glass window do with the light and heat from a fire?

It permits the light to pass through; but it stops the heat.

How may this be proved?

When a pane of glass is held between the face and a fire, it will protect the face from the heat.

Is there any heat without light?

Yes; many substances contain heat, but do not emit light.

Does light change the amount of heat in a substance?

No; boiling water is as hot in the dark as it is in the light; and ice is as cold in the daytime as it is at night.

Is there any other source of heat?

Yes; heat is produced by rubbing or striking substances together.

What will result from rubbing two pieces of wood together?

They may be rubbed until they take fire.

How do Indians kindle fires?

By rubbing two pieces of wood together until they take fire.

How is heat produced by the brakes on railroad cars?

It is produced by the car-wheels rubbing against the brakes.

What may be seen when a horse strikes his shoes against a stone?

Small sparks of fire, which contain heat, may be seen.

If a piece of iron be hammered, will its heat be increased?

Its heat will be increased.

How can this be proved?

A person can, by hammering a piece of cold iron, make it red-hot.

Could we live without heat?

No; our bodies must be kept warm, and this can be done only by heat.

Is this true of other living things?

Yes; all the animals and all the plants would die if heat were taken away.

How should we feel in regard to these things?

We should feel thankful to an All-wise Creator, for having provided us with both heat and light from a never-failing source — the sun.

Expansion by Heat.

How does heat generally affect substances?

Heat *expands* them or makes them larger.

Does heat expand all metals?

Yes; all metals are expanded by heat.

When a rod of iron is heated, is it longer or shorter than when cold?

It is longer than when it is cold.

How do we know this?

We know it by measuring the rod when it is cold, and again when it is heated.

Will the rod be larger, as well as longer?

The rod will be larger.

How can we prove this?

The rod, when red-hot, will not go through as small a hole as when it is cold.

How do heat and cold affect most substances?

Heat expands most substances, and cold contracts them.

Do all metals expand alike by heat?

No; some metals expand much more than others.

How does heat expand substances?

Heat pushes the parts or atoms of an object farther from each other, and thus its size is increased.

What does a blacksmith do with a tire before putting it on a wheel?

He heats the tire red-hot.

Why does he heat the tire red-hot?

So that it will be increased in size, and will go on the wheel more easily.

What takes place as the tire cools?

It becomes smaller, and thus binds the parts of the wheel tightly together.

When a fire is made in a room, why does the furniture often make a snapping noise?

Because heat expands the wood, and the particles make a snapping noise upon separating.

Why does a stove make a crackling noise as it grows hot?

The particles of the iron make the noise in expanding.

If a piece of glass be held in the hand, will the glass become warm?

The glass will become as warm as the hand.

What part of the glass will be warmed first?

The part touching the hand will be warmed first.

What part of the glass will be warmed last?

The part farthest from the hand will be warmed last.

Which part of the glass will be expanded first?

The part touching the hand, because it is first warmed.

Which part will be expanded last?

The part farthest from the hand, because it is the last part warmed.

If any other warm substance touch the glass, will the glass be heated in the same manner?

The glass will be heated in the same manner.

What often results from this unequal heating?

The glass is broken.

Why are glass plates or tumblers broken when placed in hot water?

They are broken because the part next to the hot water is expanded more than that farther away.

Why will a cloth dipped in hot water and wrapped around the neck of a bottle loosen its stopper?

Because the heat from the cloth expands the neck of the bottle before it does the stopper, so that the stopper is loosened.

Why do stove-plates often break?

Because they are fitted together in the stove so that they have not room to expand without breaking.

What effect has cold upon substances?

Cold causes them to contract or grow smaller.

Things *expand* unequally; do they also *contract* unequally?

They do contract unequally, and in this way may be broken.

Why are lamp chimneys often broken while the lamp is burning?

Because the heat of the flame causes them to expand unequally.

In what other way are they broken?

By a draught of cold air, or a drop of cold water, touching them, thus causing them to contract unequally.

Why are they sometimes broken when the lamp is not burning?

Because a current of cold air from a window or a door, blows upon them.

Does quicksilver expand when heated?

Like other metals, quicksilver expands as it grows warmer, and contracts as it grows cooler.

Is quicksilver in the form of a solid or a fluid?

It is a fluid as we usually see it.

For what is quicksilver used?

It is used for filling the tubes of thermometers.

What is a Thermometer?

It is an instrument used for measuring the degree or quantity of heat in any substance.

How does heat affect the quicksilver?

Heat expands the quicksilver, and causes it to rise in the tube.

How does cold affect the quicksilver?

Cold contracts the quicksilver, and causes it to fall in the tube.

Does heat expand liquids more than solids?

Heat does expand liquids more than solids.

Why are liquids expanded more than solids?

Because the particles of which they are formed are more easily separated or pushed apart by the heat.

If we continue to apply heat to a liquid, what becomes of it?

The liquid is changed into a gas or vapor.

What common example have we of vapor?

Water, when heated, is turned into steam.

Mention some gas.

The *air* we breathe is a gas.

How does heat affect the air?

Heat warms the air and causes it to expand.

Do solids all expand equally when heated?

No; some solids expand more than others; thus, zinc expands more than iron, and iron more than glass.

Do liquids all expand equally when heated?

No; liquids, although more sensitive to heat, do not expand as equally as solids.

Do gases expand equally when heated?

Yes; gases expand uniformly; thus, 491 cubic inches of any gas, if heated one degree, will become 492 cubic inches.

If one cup be filled with lead, and another cup of the same size with water, which will weigh the more, the lead or the water?

The lead will weigh more than the water.

Which is the heavier substance, lead or water?

Lead is heavier than water.

Why do we say lead is heavier than water?

Because a cup full of lead will weigh more than the same cup full of water, or any bulk of lead will weigh more than an equal bulk of water.

Why is cork lighter than water?

Because any bulk of cork is lighter than an equal bulk of water; a cup filled with cork will weigh less than when it is filled with water.

When lead is put in water, why does it sink to the bottom?

Because the lead is heavier than an equal bulk of water.

When cork is put in water, why does it rise to the surface?

Because the cork is lighter than an equal bulk of water.

Does heat increase the weight of any substance?

Heat does not increase the weight of any substance.

How do we know this?

Because a piece of iron when cold will weigh as much as when heated red-hot.

When a liquid is heated, does it become lighter or heavier?

It becomes lighter, bulk for bulk, when heated.

Why does a liquid become lighter when heated?

Because the same liquid is expanded and takes up more room, although it has no more weight.

Why will a gallon of cold water weigh more than a gallon of hot water?

Because a gallon of cold water, when heated, will make more than a gallon of hot water.

When do we get the most molasses, by buying it in hot or in cold weather?

We get the most by buying it in cold weather, because a gallon bought then will make more than a gallon when the weather becomes warmer.

Does heat expand the air and make it lighter?

Heat does expand the air and make it lighter.

What does the air do when heated?

It ascends or rises up, because it is lighter, and the cold or heavier air falls to take its place.

What part of a room, in which there is fire, is the warmest?

The part next to the ceiling is the warmest, because the heated air always ascends.

Why does a soap-bubble ascend?

Because it is filled with heated air from the lungs, and is, therefore, lighter than the air around it.

Why do balloons ascend?

Because they are filled with a gas lighter than the air around them.

Why does a chestnut split open when roasting?

Because the air in it is expanded by the heat, so that it bursts the shell.

Why does the chestnut not split open when a hole is made in the shell?

Because the air can then escape as it expands, without bursting the shell.

What becomes of the air in an apple, when the apple is roasted?

The air, upon being heated, bursts through the peel of the apple, carrying the juice with it.

Why does an apple become soft when roasted?

Because the air in the cells of the apple expands, and breaks those cells, so that the apple becomes soft.

What part of the apple first becomes soft?

The outside, because it is first heated.

Why do all fruits and vegetables become soft when cooked?

Because the heat expands the air in them, and thus breaks up their cells, so that they become soft.

Why does wood make a snapping noise when burning?

Because the air in the cells of the wood bursts them apart, thus making the noise.

Why are sparks of fire thrown out?

Because the heated air bursts the cells with such force as to throw off small pieces of the burning wood.

What kinds of wood snap the most?

The coarse-grained kinds, like chestnut; while the finer-grained kinds, like walnut, seldom snap much.

Why does dry wood snap more than green wood?

Because the sap in the pores of the green wood dries up as the wood becomes dry, and its place is filled with air, so that there is more air in dry wood than in green wood.

Why does smoke rise in a chimney?

Because the air in the chimney is heated by the fire, and as the air rises, it carries the smoke with it.

Why does a chimney smoke when the fire is first kindled?

Because the cold walls of the chimney cool the heated air so rapidly as to prevent its rising to the top, and the smoke then sinks back into the room.

How are houses heated with hot air?

By having the fires made in the cellar, so that the air when heated, may ascend through pipes to the different parts of the building.

Is there any substance that does not contract by cold?

Yes; water, when near freezing, does not contract by cold.

What takes place with the water?

When it is reduced nearly to the freezing point, it begins to expand, and when it freezes, it expands still more.

How much does water expand by freezing?

It expands about one-seventh of its bulk. That is, *seven* gallons of *water* will make *eight* gallons of *ice.*

Does freezing water expand with much force?

Yes; it expands with great force.

Why are vessels containing water often broken during a cold night?

As the water in them freezes, it expands and breaks the vessels.

Why do lead pipes and iron pipes often burst during the winter?

Because the water in them is permitted to freeze, and as there is not room for it to expand, the pipes are burst.

Is ice heavier or lighter than water?

Ice is lighter than the same bulk of water.

How much lighter is ice than water?

Eight gallons of ice weigh no more than seven gallons of water.

Does the ice protect the water beneath it from freezing?

Ice does protect the water from freezing, to a very great extent.

If ice were heavier than water, what would result?

The ice would sink as rapidly as formed, and our streams would, every winter, freeze to the bottom, thus destroying the fish and other creatures living in them. In this, as in many other ways, we may learn the lesson, that in the creation of the world, God wisely made all things to serve some useful purpose.

Conduction of Heat.

Why does iron feel cold to the touch on a cold morning?

Because heat goes from the hand to the iron, thus giving the sensation of cold.

What is the passage of heat from the hand to the iron called?

It is called *conduction.*

When one end of a rod of iron is placed in a fire, does the whole rod become heated?

The whole rod does become heated.

How does this take place?

The heat of the fire passes from one particle to another throughout the rod.

What is this called?

It is called *conduction.*

What then is conduction of heat?

It is the passage of heat from one body to another which it touches, or from one particle of a body to another particle of the same body.

What bodies are good conductors of heat?

Such bodies as gold, platinum, copper, silver, iron, zinc, tin, and lead, in the order named, are the best conductors of heat.

What bodies are poor conductors of heat?

Such bodies as glass, wood, charcoal, wool, hair, and fur.

Fur is the poorest conductor of heat known.

Why does a piece of wood blazing at one end not feel hot at the other end?

Because wood is a poor conductor, and the heat goes slowly through it.

Why does a piece of iron feel cold in winter?

Because the iron is a good conductor, and carries the heat away from our hands very rapidly.

Why does fur feel warmer than iron in the winter?

Because the fur is a poor conductor, and carries the heat away from our hands very slowly.

Why does a wooden pump-handle seem less cold than one of iron?

Because wood is not so good a conductor as iron; hence, it does not carry the heat of our hands away so rapidly.

Why does carpet seem warmer than the bare floor?

Because the carpet is a poorer conductor than the wood of the floor, and does not carry away the heat of our bodies so rapidly.

Why does a stone pavement make our feet cold in winter?

Because the stone is a good conductor, and rapidly carries the heat away from our feet.

Why does heated iron feel hot to us?

Because the iron is a good conductor, and gives off its heat rapidly to our bodies.

Why does a piece of cloth, when heated, not feel hot?

Because the cloth is a poor conductor, and gives off its heat very slowly.

Why will a block of wood, when heated, remain hot longer than a heated brick?

Because wood is a poorer conductor than brick, and does not give off its heat so rapidly.

Why is a block of wood better than iron or brick, to keep our feet warm while on a journey?

Because it does not give off its heat so rapidly, and therefore remains warm longer than iron or brick.

Why should the wood or brick be wrapped in cloth?

Because the cloth, being a poor conductor, helps to keep the heat from passing off so rapidly.

Why does iron feel colder than water when both are at the same temperature?

Because iron is a better conductor than water, and carries away the heat from our hands more rapidly.

Are liquids good conductors of heat?

No; liquids are poor conductors of heat.

Is air a good conductor of heat?

No; air is a poor conductor of heat.

Are gases as good conductors as liquids?

No; gases are poorer conductors than liquids.

Why is water a better conductor than air?

Because the particles of water are closer together than the particles of air.

Why is iron a better conductor than water?

Because the particles of iron are closer together than the particles of water.

How do we know that water is a poor conductor of heat?

Because water may be made to boil at its surface without melting ice a short distance below the surface.

How do we know that air is a poor conductor of heat?

Because the air at the ceiling of a room may be made very warm without melting ice near the floor.

Why does a linen shirt feel cool?

Because linen is a good conductor, and there is but little air among its fibres.

Why is a cotton shirt warmer than one made of linen?

Because the cotton contains more air among its fibres, and air is a poor conductor of heat.

Why is a woollen shirt warmer than one made of cotton?

Because wool contains more air among its fibres, and is, therefore, a poorer conductor of heat.

Why is fur warmer than wool?

Because there is more air among the hairs of the fur, and it is, therefore, a poorer conductor of heat.

What fur is the warmest?

Fur with very fine hairs, like that of the rabbit, because it contains the most air.

Why is fur warmer when the hair is next to our bodies?

Because the fur and the air in it both help to keep the heat of our bodies from passing off rapidly.

Is the earth a good conductor of heat?

No; the earth is a poor conductor of heat.

How do we know that the earth is a poor conductor of heat?

Because the heat of summer warms the earth only a few inches below the surface.

How is it with the earth in winter?

In this latitude, the frost of winter reaches only a few inches below the surface of the earth.

In all parts of the earth, except in the Frigid Zones, the heat of the summer takes away the frost and ice of the winter, and the earth is warmed so that plants may grow.

Why is spring-water generally cool, even in summer?

Because the springs are mostly so far below the surface of the earth, that they are not warmed by the sun's rays.

Why is snow a warm covering for the earth?

Because the air among the particles of snow prevents the heat of the earth from passing off rapidly.

Why does wrapping straw around a pump in winter, prevent the water in it from freezing?

Because the stalks of straw are hollow, and the air in the stalks makes them poor conductors of heat.

Will straw, wrapped around shrubbery, prevent it from freezing?

It will; because it keeps the heat of the shrubbery from passing off into the air.

Why are rooms warmer from having double windows?

Because the air which is confined between the double windows, being a poor conductor, keeps the warmth of the room from escaping.

Why is the space between the double walls of ice-coolers filled with charcoal?

Because charcoal is a poor conductor, and keeps the heat of the air from the ice.

Why do ice-houses have double walls, with saw-dust or straw between them?

Because the saw-dust and the straw are both poor conductors, and keep the heat of the air from the ice.

Why does ice melt more slowly when wrapped in flannel?

Because the flannel is a poor conductor, and keeps the heat of the air from the ice.

Why are woollen holders used about the stove?

Because wool is a poor conductor, and thus keeps the heat of the iron from burning the hand.

Convection of Heat.

When air near the floor of a room is heated, what becomes of it?

It ascends to the ceiling of the room.

What is done with the cold air at the ceiling?

It descends to the floor, to take the place of the warm air.

When the air ascends to the ceiling, does it carry the heat with it?

Yes; it carries the heat with it.

What is this mode of carrying heat called?

It is called *Convection.*

What is needed so as to heat a substance by convection?

Its particles must be able to move about freely.

Why is the air easily heated by convection?

Because the particles of the air move about freely.

Why is a liquid easily heated by convection?

Because its particles move about freely.

Why cannot a solid be heated by convection?

Because its particles cannot move.

When water near the bottom of a vessel is heated, what becomes of it?

It rises to the surface.

What becomes of the cold water at the surface?

It falls to the bottom of the vessel, to take the place of the warm water.

How long will this circulation continue?

It will continue so long as heat is applied to the bottom of the vessel.

When heat is applied to the surface of the water, what is the result?

The water near the surface only is heated.

Why does it not heat all the water in the vessel?

Because the water when heated, becomes lighter, and stays at the surface, while the cold water is heavier and remains at the bottom of the vessel.

Where must heat be applied to warm a liquid or a gas?

It must be applied to the bottom of the vessel containing the liquid or the gas.

Where must a fire be, so as to warm a room?

The fire must be near the floor of the room.

Why does a hot substance cool quickly in the air?

Because the air touching a substance ascends as soon as heated, and cold air takes its place; as this process goes on rapidly, the substance is quickly cooled.

How is water cooled by convection?

The water at the surface is cooled by giving off its heat to the air; it then falls to the bottom, and the warm water rises to take its place at the surface.

Why does stirring hot coffee cool it quickly?

Because the hot coffee at the bottom of the vessel, is brought more rapidly in contact with the air, and, therefore, gives off its heat more rapidly.

Why does blowing hot coffee cool it quickly?

Because the hot air over the coffee is removed by blowing, and the cold air is brought more rapidly in contact with the coffee.

Liquefaction.

Is ice a solid or a liquid?

Ice is a solid.

When heat is applied to ice, what becomes of the ice?

The ice is changed into water.

Is water a liquid?

Water is a liquid.

How then can a *solid* be changed to a *liquid*?

By applying *heat* to a solid, it may be changed to a liquid.

What is meant by liquefaction?

Liquefaction is the changing of a solid to a liquid, by heat.

How may tallow be melted?

By heating the tallow, it may be melted.

Will the tallow become hard again when cold?

It will be hard again when cold.

Can lead and other metals be melted?

They can be melted or changed to a liquid state by heat.

Can all solids be changed to liquids?

No; there are many solids, such as wood, coal, paper, and leather, that cannot be changed to liquids.

How can a liquid be changed to a solid?

By taking heat away from the liquid, it may be changed to a solid.

Why is a solid melted by heat?

Because heat forces the particles of the solid apart, until it is changed to a liquid.

Latent Heat.

Why does warm iron feel warm to the hand?

Because it gives off some of its heat to the hand.

Is the hand sensible of the heat coming from the iron?

The hand is sensible of the heat.

What then may this heat be called?

It may be called *sensible* heat, because it can be felt.

How do we measure heat?

We measure heat by degrees.

How many degrees of heat in ice when at the melting point?

Thirty-two degrees of heat, as measured by the thermometer.

How can we change ice into water?

By applying heat to the ice it will be changed into water.

How many degrees of heat are necessary to change the ice into water?

One hundred and forty degrees of heat are necessary.

How many degrees of heat are in the water when the ice is all melted?

Only thirty-two degrees of heat, by the thermometer.

Does the water feel any warmer than the ice to the hand?

No; the water does not feel any warmer than the ice.

What has become of the one hundred and forty degrees of heat?

They have been hidden in the water.

What is this hidden heat called?

It is called *latent* heat.

What is latent heat?

It is heat that is not sensible to the touch, or to the thermometer.

When water is made to boil, what change takes place?

The water is changed into steam.

How many degrees of heat are necessary to change water into steam?

More than nine hundred degrees of heat are necessary.

How many degrees of latent heat in steam?

More than nine hundred degrees of latent heat.

When steam is changed back again to water, what becomes of the latent heat?

It passes off to the air and the surrounding objects, and makes them warmer.

When water is changed into ice, what becomes of the latent heat?

It passes off to the surrounding objects and makes them warmer.

Is freezing a warming process?

Yes; because the water gives off its latent heat while freezing; hence, the surrounding objects are made warmer.

Is thawing a cooling process?

Yes; because the ice absorbs so much heat while thawing that it cools the surrounding objects.

Where does the ice obtain its heat, while thawing?

The ice obtains its heat from the surrounding objects.

Are these objects made cooler by the melting of the ice?

They are made cooler by the melting of the ice.

What effect does salt have upon ice?

Salt makes the ice melt more rapidly.

When salt and ice are placed around a vessel of cream, what takes place?

The salt causes the ice to melt quickly, and the ice

in melting takes so much heat from the cream as to freeze it, thus making it ice-cream.

Ebullition.

What is meant by ebullition?

Ebullition means boiling.

When is a liquid in a state of ebullition?

When it has been heated so as to boil.

Can solids be made to boil?

No; liquids only can be made to boil.

What change takes place when a liquid boils?

The liquid is changed into a vapor or gas.

What becomes of water when it is boiled?

Water when boiled passes off into steam.

What is necessary to make water boil?

Heat is necessary to boil water or any other liquid.

How much heat is contained in boiling water?

Two hundred and twelve degrees of heat.

When water passes into steam, how much is its bulk increased?

About seventeen hundred times.

How much steam will a pint of water make?

A pint of water will make about seventeen hundred pints of steam.

What do bubbles of boiling water contain?

They contain steam.

Why are these bubbles formed?

Because the water at the bottom of the vessel is heated and changed into steam, which expands and forms the bubbles.

Why do these bubbles rise to the surface?

Because steam is lighter than water.

When does water simmer?

When water is heated, the steam at first forms in very small bubbles at the bottom of the vessel, and as these bubbles rise through the colder water, the steam in them is condensed to water, so that they break before reaching the surface, thus producing what is called "simmering."

When does water boil?

Water boils when it becomes heated so that the bubbles rise to the surface of the water before breaking.

Why will a vessel full of water run over when heated?

Because the water is expanded by heat, and some of it must run over.

Why will the water boil over when the vessel is not full?

Because the steam, in trying to escape, throws some of the water over the edge of the vessel.

Vaporization.

When water is boiled, what change does it undergo?

It is changed into a vapor, called steam.

What is this process called?

It is called *Vaporization.*

What is meant by vaporization?

Vaporization is the changing of a liquid into a vapor, by boiling.

What is necessary to change a liquid into a vapor?

Heat is necessary to change a liquid into a vapor.

At what temperature is water changed into steam?

At the temperature of two hundred and twelve degrees.

Are all liquids changed to vapor at the same temperature?

No; they vary very much in the amount of heat required.

Ether boils at 96 degrees, alcohol at 176 degrees, and quicksilver at a temperature of 662 degrees.

When water is changed into steam, what becomes of the steam?

The steam passes off into the air.

What does the air do with the steam?

The air condenses or changes it into very small particles of water, so that it is seen like a fog or a cloud.

Can steam be seen?

No; steam is like the air in this respect, and cannot be seen.

How can we prove this?

When water is boiled in a glass vessel, no steam is visible, although it is there.

Cannot we see the steam coming from the spout of a teakettle?

No; we do not see anything for half an inch or more from the spout.

Why does it become visible farther away?

Because the air condenses it, and then we see it in its cloud-like state.

How much steam will one gallon of water make?

One gallon of water will make seventeen hundred gallons of steam.

When this steam is confined in a vessel, what does it try to do?

It tries to expand or spread out in every direction.

Does it expand with much force?

Yes; it expands with so much force as frequently to burst the vessel containing it.

Why is the lid of the tea-kettle lifted up when the water boils?

Because the steam expands and raises the lid, so that it can escape.

If the lid were fastened down, what would result?

The steam, in trying to escape, would burst the tea-kettle.

Why does water run out of the spout of the tea-kettle?

Because the steam in the tea-kettle presses on the water with force enough to cause it to run out.

Why does steam burst vessels in which it is confined?

Because the vessels are not strong enough to keep the steam from expanding.

How is the boiler of a steam-engine kept from bursting?

By means of a safety-valve.

What is a safety-valve.

It is a valve or opening through which steam may escape.

What prevents all of the steam from escaping through the valve?

The valve is kept closed by a weight, which prevents the escape of the steam until a certain quantity of it is formed in the boiler; it then lifts up the valve, and a portion of it escapes, the same as it does with the lid of the tea-kettle.

Evaporation.

Does a wet blanket, when hung in the air, remain wet?

No; it soon becomes dry.

What becomes of the water in the blanket?

The water passes off into the air.

What is this process called?

It is called *Evaporation.*

What is meant by evaporation?

It is the gradual change of a liquid into a vapor.

When water is left in a shallow vessel, what becomes of it?

The water evaporates or passes off into the air.

Do liquids generally evaporate?

Yes; when exposed to the air, nearly all liquids evaporate.

Does water change into steam when it evaporates?

Water does not change into steam when it evaporates.

How, then, does water evaporate?

It passes off into the air in particles or drops so very small as not to be visible.

Is evaporation always going on around us?

Yes; wherever there is water exposed to the air, evaporation is taking place.

Where does the most evaporation take place?

From the surface of the rivers, the lakes, and the ocean.

What becomes of the water when evaporated?

It is formed into fogs and clouds.

In what kind of air does evaporation go on most rapidly?

In air that is warm and dry.

Does evaporation take place in cool air?

It does; because clothing will dry during the coldest weather of winter.

Why does water evaporate more in warm air than in cold air?

Because the warm air can hold more of the fine particles of water, and, therefore, can absorb more.

Why does water evaporate more slowly in damp weather than in dry weather?

Because the damp air contains so much moisture that but little more can pass off into it.

What example have we of this?

Wet clothes dry much more slowly when the air is damp than when it is dry.

Why do clothes dry more rapidly in windy weather?

Because the damp air in contact with them is blown away, and the dry air is constantly taking its place.

Is heat necessary in evaporation?

Heat is necessary to produce evaporation.

Why do our hands feel cold when wet?

Because the water on our hands evaporates, and thus heat is taken from them.

Why is the air cooler after a rain?

Because evaporation then takes place from every wet object, and this absorbs heat from the air.

Why does watering streets and roads cool the air?

Because the water evaporates and absorbs heat from the air, making it cooler.

Why do we feel cold when our clothes are wet?

Because the moisture in them evaporates and absorbs heat from our bodies.

Why is wet land always cold?

Because so much heat is absorbed from the land in the evaporation which is constantly taking place.

What becomes of the dew that collects on plants and other objects at night?

It is evaporated.

How does the sun hasten the evaporation of the dew?

By supplying the heat needed to change the dew into a vapor, the sun hastens its evaporation.

Why do bread and biscuit become hard when kept a few days?

Because the moisture in them passes off into the air, and thus they become dry and hard.

How can they be kept moist and soft for a longer time?

By keeping them in a covered vessel, so that evaporation will take place more slowly, they may be kept moist for a longer time.

Radiation.

When we stand near the fire, why do we feel warm?

Because the fire gives off heat which makes us feel warm.

How does the fire give off heat?

It gives off heat in straight lines, and in every direction.

What is this giving off of heat called?

It is called *Radiation* of heat.

Does the sun radiate heat?

The sun does radiate or give off both heat and light.

How do heat and light from the sun come to us?

They come together in the sunbeam.

Does heat travel as rapidly as light?

Yes; heat and light travel together at the rate of 200,000 miles in a second of time.

Do all substances radiate heat equally well?

No; some substances are much better radiators than others.

What kind of objects are the best radiators?

Those with rough and dark surfaces.

What kind of objects are the poorest radiators?

Those with smooth and bright surfaces.

Why does water keep hot a long time in a bright tin vessel?

Because the tin is a poor radiator, and prevents the heat of the water from passing off into the air.

Why does water soon cool in a dull earthen vessel?

Because the earthen vessel is a good radiator, and gives off the heat of the water rapidly.

If the bright tin vessel be painted, will the water keep hot so long?

No; the tin becomes a good radiator when painted, and the water is soon cooled.

Why does a stove cool so quickly?

Because the iron is a good radiator, and gives off its heat rapidly.

Do the rays from the sun give off much heat while passing through the air?

The rays from the sun give off about one-fourth of their heat while passing through the air.

What becomes of the remaining heat from the sun?

It is absorbed or reflected at the earth's surface.

What does the earth do with the heat?

The earth radiates the heat, and thus warms the air.

Reflection.

When a piece of bright tin is held near the fire, does the tin become hot?

No; the tin is scarcely warmed.

What does the tin do with the rays of heat from the fire?

The tin throws them back from its surface.

What is this called?

It is called *Reflection* of heat.

Do all substances reflect heat equally well?

No; some reflect much more heat than others.

What kind of objects reflect heat the best?

Those with bright and smooth surfaces.

What kind of objects reflect heat the least?

Those with rough and dark surfaces.

Does bright tin reflect heat better than glass?

Yes; bright tin reflects about eight times as much heat as glass does.

Why does it take so long to heat water in a new tin cup?

Because the bright tin is a good reflector, and throws off the greater part of the rays of heat that come to it from the fire.

Why does a piece of tin or other bright metal, placed under a stove, protect the carpet from burning?

Because the tin being a good reflector, remains cool, and cannot burn the carpet under it.

Why will not a piece of iron protect the carpet from burning?

Because the iron, being a poor reflector, soon becomes heated, so as to burn the carpet under it.

Absorption.

When a piece of iron is held near a fire, does the iron become hot?

Yes; the iron soon becomes hot.

How is the iron heated?

The iron absorbs or takes in the heat from the fire.

What is this power to take in the heat called?

It is called *Absorption* of heat.

What is this process like?

It is somewhat like a sponge, that absorbs or sucks up moisture.

Do all substances absorb heat equally well?

No; some substances absorb more heat than others.

What kind of objects absorb heat the best?

Those with rough surfaces absorb heat the best.

What kind of objects absorb heat the least?

Those with bright and smooth surfaces.

What colored objects absorb heat the best?

Objects of a dark or black color.

Do objects that absorb heat well, radiate well?

Yes; good absorbers are good radiators.

Why is this?

Because every substance must absorb heat before it can have heat to give off.

Do objects that absorb heat well, reflect it well?

No; objects that absorb heat well, cannot reflect it well.

Why is this?

Because a ray of heat cannot be reflected from an object, and be absorbed by that object, both at the same time.

Why is water rapidly heated in a tea-kettle?

Because the rough, dark iron of the tea-kettle absorbs the heat from the fire, and gives it off rapidly to the water contained in the kettle. The iron is also a good conductor of heat; therefore, the heat from the fire passes rapidly through it to the water.

Why does black cloth, when spread on the snow, cause the snow to melt more rapidly?

Because the cloth absorbs heat from the rays of the sun, and, therefore, melts the snow beneath it.

Why does not white muslin, when spread on the snow, hasten its melting?

Because the white muslin reflects the heat from the rays of the sun, so that but little of it enters the snow.

Does the snow receive much heat from the sun?

Snow is a good reflector, and throws back most of the heat from the sun.

What causes the snow to melt?

The heat it receives from touching the earth, causes the most of it to melt.

Why does snow melt first on dark earth?

Because dark earth is a good radiator, and gives off much heat to the snow.

Why does snow remain longest on light-colored earth?

Because the light-colored earth is a poor radiator, and gives off but little heat to the snow.

Why does the air feel cold in winter time?

Because it is so much cooler than our bodies that it absorbs heat from them rapidly, and thus makes them feel cold.

Why does the air feel warm in summer time?

Because it is then nearly as warm as our bodies, and, therefore, absorbs heat from them slowly.

Why are greasy shoes warmer than those polished with blacking?

Because the greasy shoes absorb heat from the sun, but the polished shoes throw off the heat of the sun by reflection.

What may we remember about heat?

And God said, Let there be light; and there was light. But along with the light, came its companion — heat; for when the sunbeam first came forth at His command, the twin sisters, light and heat, together touched the earth, causing it to bloom with life and beauty. And the earth brought forth grass, the herb yielded its seed, and the tree its fruit: And God saw that it was all good.

CHAPTER IV.

THE AIR.

WHERE do we find air?

We find air everywhere around the earth.

Does the air fill every place?

The air fills every place not filled by some other substance.

When we say a bottle is empty, what do we mean?

We mean that it does not contain anything but air.

What do all vessels contain when empty?

All vessels contain air when seemingly empty.

Do all liquids contain air?

Yes; all liquids contain air.

Where is the air in a liquid?

The air is among the particles which compose the liquid.

Is there air in water?

Yes; there is air in water.

Of what use is the air in the water?

It is used by the fish and other creatures that live in the water.

How do the fish and other creatures use it?

They breathe it into their lungs, and it supports life in them, the same as the air which we breathe supports life in us.

Do solids contain air?

Yes; solids contain more or less air.

Where is the air in fur and in wool?

It is among the hairs of the fur and the wool.

Where is the air in cotton and linen goods?

It is among the fibres of the cotton and the linen.

Where is the air in fruit?

It is among the particles composing the fruit.

Where is the air in wood?

It is in the pores or small spaces in the wood.

Is there air in the earth?

Yes; there is air among the particles of the earth.

How deep in the earth does the air extend?

We cannot tell; but both air and water have been found several hundred feet below the earth's surface.

Of what use is the air in the earth?

It is breathed by the worms and other creatures that live in the earth.

When part of the air is taken from a room, what becomes of the air left in the room?

It expands so as to fill the whole room.

Are the particles of air so close together after it expands as they were before?

They are not so close together.

When air is thus expanded, what is said of it?

It is said to be *rare*.

When pressure is put upon air in a vessel, what becomes of the air?

It is forced or pressed into a smaller space, and, therefore, occupies less room.

When pressure is put upon air, are its particles closer together?

They are closer together.

When air is thus compressed, what is said of it?

It is said to be *dense.*

Can air be much condensed by pressure?

It has been condensed so much that 100 cubic feet of air was reduced to the bulk of only one cubic foot.

What makes the air so dense as it is at the surface of the earth?

The pressure of the air above the surface.

Does the air then become less dense the higher we ascend?

Yes; because there is less air above to press upon it.

Does the air become more dense the deeper we go in the earth?

It does; because there is more air above to press upon it.

How can we understand this?

In a large heap of wool, the hairs of the wool at the bottom of the heap are pressed closely together, but they are farther and farther apart the nearer they are to the top of the heap.

How high does the air extend above the earth?

It is supposed to extend to the height of *fifty* miles.

Do these fifty miles of air press upon the earth?

They do press upon the earth.

With how much force does the air press on the earth?

With a force of *fifteen* pounds on every square inch of surface.

Then has the air weight?

The air has weight.

Why do we not feel the weight of the air?

Because it presses with equal force, in every direction; up, down, and on every side.

How can we show that the air presses upwards?

Fill a tumbler with water and put a piece of writing-paper over the top. Hold the hand on the paper and quickly invert the tumbler, or turn it bottom upwards; then remove the hand, and the pressure of the air against the paper will keep the water in the tumbler. This is represented in Fig. 12.

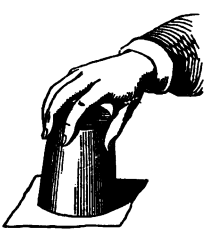


Fig. 12.

If a tumbler be filled with water in a bucket, and then raised bottom upwards until its edge is just below the surface of the water, it will remain full of water; why is this?

The pressure of the air on the water in the bucket, keeps the water in the tumbler.

If we use an iron pipe or a lead pipe, instead of a tumbler, will the pressure of the air keep the water in the pipe?

It will, the same as it keeps it in the tumbler.

How high will the air keep the water in the pipe?

It will keep the water to the height of *thirty-four* feet.

Why does the air keep the water up thirty-four feet?

Because the air presses down with a force of fifteen pounds on every square inch of surface, and a column of water thirty-four feet high presses down with a force of fifteen pounds on every square inch of surface.

Does the weight of the air exactly balance the weight of the column of water?

It does; they balance each other.

Is water heavier than air?

Water is heavier than air; because a column of water thirty-four feet high weighs as much as a column of air fifty miles high.

Is quicksilver heavier than water?

Yes; quicksilver is about thirteen times heavier than water.

How high a column of quicksilver can the air keep up?

The air can keep up a column of quicksilver only *thirty* inches high.

Why is this?

Because a column of quicksilver thirty inches high, weighs exactly the same as a column of air fifty miles high, or a column of water thirty-four feet high.

How can this be shown?

Take a glass tube about thirty-three inches long, cork up one end, and fill the tube with quicksilver; then put the open end of the tube beneath the surface of some quicksilver, in a basin, and the quicksilver in the tube will fall to the height of thirty inches, as is shown in Fig. 13.

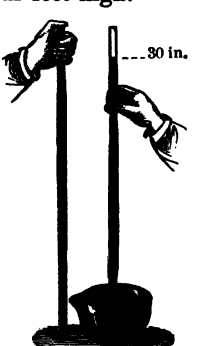


Fig. 13.

If the cork be removed from the glass tube, what will become of the quicksilver?

It will immediately sink into the basin below.

Why will the quicksilver sink into the basin?

Because the air will then press upon the quicksilver in the tube, the same as it does on that in the basin; hence, all the quicksilver will fall to the same level.

Does the weight of the air vary at different times?

Yes; the air does vary in weight at different times.

How can we tell when the air changes in weight?

By means of a *Barometer.*

What is a barometer?

It is an instrument having a tube filled with quicksilver.

When the air is heavier, how does it affect the quicksilver?

The quicksilver rises in the tube.

When the air is lighter, how does it affect the quicksilver?

The quicksilver sinks in the tube.

What is the use of the barometer?

It shows the changes about to take place in the weather.

When the quicksilver rises, what kind of weather is indicated?

It indicates fair weather.

When the quicksilver sinks, what kind of weather is indicated?

It indicates cloudy or stormy weather.

Where is the barometer most useful?

It is most useful at sea, to warn the sailors of coming storms.

What use is it to farmers?

They can use it as a guide when planting and gathering their crops, and thus be better prepared for stormy weather.

For what else may the barometer be used?

It may be used to tell the height or depth of any place.

Does the air become lighter as we ascend?

The air does become lighter as we ascend.

How does this affect the barometer?

As the air becomes lighter, the quicksilver in the barometer sinks lower.

At what height does the quicksilver stand at the level of the sea?

It stands at the height of thirty inches.

When we ascend a mountain 10,000 feet high, how much does the quicksilver sink?

It sinks ten inches, and, therefore, stands at the height of only twenty inches.

Does the same thing take place when we ascend in a balloon?

Yes; the higher the balloon ascends, the lower the quicksilver in the barometer sinks.

When we descend into the mines dug in the earth, does the air become heavier?

It does; and the quicksilver in the barometer rises.

At what temperature does water boil?

Water boils at a temperature of *two hundred and twelve* degrees.

When the weight of the air is taken off, will the water boil at a lower temperature?

Water will then boil at a lower temperature.

Where will water boil at the lowest temperature, on a mountain, or in a valley?

It will boil at the lowest temperature on a mountain.

At how much lower temperature will water boil, as we ascend?

Water will boil at one degree less for every five hundred feet we ascend.

How high is the city of Quito, in South America?

Quito is nine thousand feet above the level of the sea.

At what temperature does water boil there?

Water boils, in Quito, at a temperature of one hundred and ninety-four degrees.

Will an egg boil hard at Quito?

No; because the water passes off into steam at one hundred and ninety-four degrees, and it requires more than one hundred and ninety-four degrees of heat to boil an egg hard.

Do persons, while ascending mountains, often have difficulty in cooking their food?

They do, on account of water boiling there at a temperature below two hundred and twelve degrees.

What is a *vacuum*?

A *vacuum* is a place that does not contain anything, not even air.

When a vessel contains water and we pour the water out, does that produce a vacuum?

No; because air passes in and fills the vessel.

How then can a vacuum be produced?

A vacuum in any place, can be produced only by drawing the air out of it.

When a vacuum is produced, what does the surrounding air try to do?

It tries to get in so as to fill the vacuum.

With what force does the air try to fill a vacuum?

With a force of fifteen pounds on every square inch of surface.

When a vacuum is produced in contact with a liquid, what does the liquid do?

The liquid tries to pass in to fill the vacuum?

Can there be a vacuum in contact with a gas or a liquid?

No; because the gas or the liquid will instantly fill the vacant space.

Why does water make a gurgling noise when poured out of a bottle?

Because air is passing into the bottle at the same time that the water is coming out, and the air makes the noise in passing through the water.

Why does water make a gurgling noise when running out of a barrel?

Because the air passes into the barrel at the opening where the water passes out, and thus the noise is made.

How can the gurgling noise be prevented?

By making an opening at the top of the barrel, so as to admit the air.

Does water flow freely from a vessel that has but one opening?

No; because part of this opening is needed to admit air into the vessel.

Why does the water flow freely, when there is an opening at the top as well as at the bottom of the vessel?

Because air is admitted at the top, and there is then nothing to obstruct the flow of water from the opening at the bottom.

What causes fruit, vegetables, and meat to spoil?

The air causes them to spoil.

How do we know this?

Because when kept from the air they remain good for a long time.

What is this process of keeping fruit called?

It is called canning.

How is fruit canned?

The fruit is put into a glass jar, or into a tin can, along with some water, and then heated until the jar or can is filled with steam and the air is all forced out; it is then sealed so as to be air-tight, and, in this condition, may be kept for many months.

What becomes of the steam in the jar or can?

As the fruit cools, the steam is condensed to water, and a vacuum is produced, so that the fruit is kept from the air.

What is the plaything which boys call a sucker?

A *sucker* is a round piece of leather, with a string fastened to its centre.

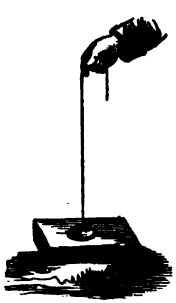


Fig. 14.

How is the sucker used?

The leather is made very soft and wet, so that when pressed against a stone or brick, all the air under the leather is forced out; and when the leather is lifted up, the stone or brick is lifted with it, as is represented by Fig. 14.

What keeps the leather against the stone?

The pressure of the air upon the leather keeps it against the stone.

With how much force does the air press the leather against the stone?

With a force of fifteen pounds on every square inch.

When there is air between the stone and the leather, can the stone be lifted with the sucker?

It cannot; because the air under the leather will press it up as much as the air above will press it down.

How does a fly walk upon the ceiling?

The fly's feet are much like the sucker, and are kept against the ceiling by the pressure of the air.

How do snails cling to objects?

They force out all the air between the object and their bodies, and are then held against the object, as the sucker is held against the stone.

What is a *siphon*?

A *siphon* is a bent tube, having one branch longer than the other, as is represented in Fig. 15.

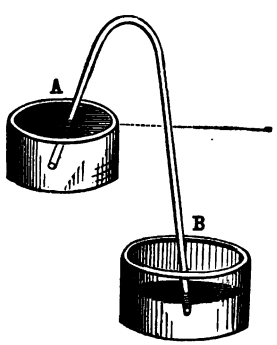


Fig. 15.

For what is the siphon used?

The siphon is used to draw liquids from one vessel into another.

How can water be drawn from a vessel by means of a siphon?

Put the short branch in the water, then, by means of the mouth applied to the long branch, suck the air from it, and the water will begin immediately to flow from the long branch.

Where must the open end of the short branch be kept?

It must be kept beneath the surface of the water, so as to prevent air from entering the tube.

Where must the open end of the long branch be kept?

It must be kept lower than the open end of the short branch.

While the water is running out of the long branch, what is produced at the bend of the tube?

The tendency is to produce a vacuum at the bend of the tube.

What is the result of this?

The water is continually forced up the short branch to fill this vacuum, so that it runs out of the long branch in a steady stream.

How do boys often suck cider from a barrel?

By means of a straw.

How is this done?

One end of the straw is placed in the cider, and the other end in the mouth; then the air is sucked out of the straw, and the cider is forced up to fill the vacuum. When the cider is sucked out, more cider is forced up, so that the straw is kept full.

What makes the cider rise to fill the vacuum in the straw?

The pressure of the air on the cider in the barrel.

To what height will water rise in a tube to fill a vacuum?

The water will rise to the height of thirty-four feet.

To what useful purpose is this applied?

It is applied to making *pumps*.

Of what material are pumps made?

Either of wood, or of metal, such as lead or iron.

What is necessary in regard to the tube or pump-tree?

It must always be air-tight.

Why must the tube or pump-tree be air-tight?

So that a vacuum may be produced in it.

How is this accomplished?

By means of two valves in the pump-tree.

What is a valve like?

A valve is like the lid on a tea-kettle, or the cover on an inkstand; and it is kept in its place by a hinge on one side.

Where is one valve placed?

One valve is placed in the lower part of the pump-tube.

How near the water must this valve be?

It must be within thirty-four feet of the water.

Why must the lower valve be within thirty-four feet of the water in the well?

Because the air can force water up a tube only to the height of thirty-four feet.

Does this valve move about in the pump-tube?

No; it remains fixed in one place.

Is this valve air-tight?

Yes; the lower valve or bucket in a pump must always be air-tight.

Where is the upper valve?

It is fastened on the end of a rod, which is attached to the pump-handle.

Does this valve remain fixed in one place?

No; it moves up and down when the pump-handle is moved.

Is the upper valve air-tight?

No; the upper valve is not air-tight.

Explain the working of a pump?

When the pump-handle is lowered, the water, above

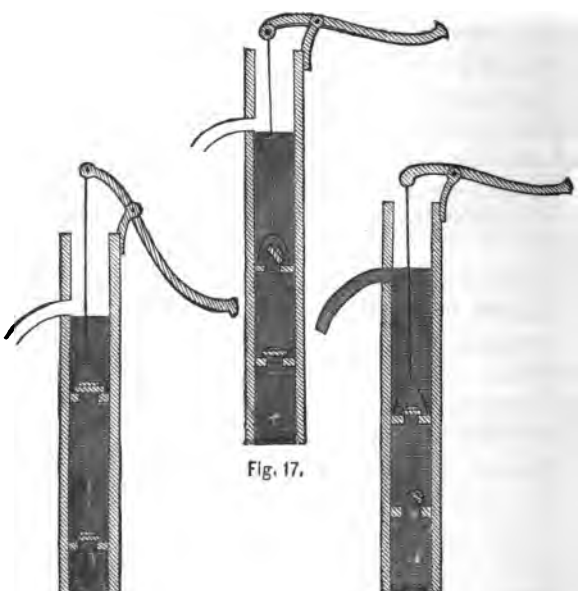


Fig. 17.

Fig. 16.

Fig. 18.

the valve or bucket attached to the end of the rod, is raised so that it runs out at the spout; and the vacuum, thus produced by raising the water, is filled by the water in the well, which is forced up the pump-tube by the pressure of the air. When the pump is at rest, the lower valve, which is air-tight, prevents the water from sinking back into the well, so that the pump-tube is always full of water, whether we are pumping or not.

What does Fig. 16 represent?

It represents a pump, when it is not working.

How are the valves?

The valves are both closed.

What keeps the water above the lower valve?

The lower valve is air-tight, and, therefore, water-tight, so that it keeps the water above it.

What keeps the water in the tube below the lower valve?

The pressure of the air on the water in the well, forces it up the tube to the lower valve.

What does Fig. 17 represent?

It represents a pump, when the handle is being raised.

How is the lower valve?

The lower valve is closed.

Why is the lower valve closed?

So as to prevent the water from being forced back again into the well.

How is the upper valve?

The upper valve is open.

Why is the upper valve open?

So that the water may pass up through the valve, while the valve is descending.

What does Fig. 18 represent?

It represents a pump when the handle is being lowered.

How is the upper valve?

The upper valve is closed.

Why is the upper valve closed?

So as to lift up the water which is above it.

What becomes of the water which is lifted up?

It runs out of the spout of the pump.

As the upper valve is raised up, what is produced under it?

A vacuum is produced under it.

How is this vacuum filled?

The water below the lower valve is forced up, so as to fill the vacuum.

How is the lower valve?

The lower valve is open.

Why is the lower valve open?

So that the water may pass through and fill the vacuum above the valve.

Where are pumps mostly used?

Pumps are mostly used by people in the country, for the purpose of obtaining water from the wells which have been sunk in the earth.

When does smoke ascend through the air?

When smoke is lighter than the air, it ascends through it.

When does smoke descend through the air?

When smoke is heavier than the air, it descends through it.

Why does a cork rise to the surface of the water?

Because the cork is lighter than the same bulk of water; hence, it ascends to the surface.

Why does heated air ascend?

Because it is lighter than the cold air.

If a feather be put in the heated air, will it be carried up with the air?

The feather will be carried up with the air.

If warm air be confined in a bag, will it rise up and carry the bag with it?

It will rise up and carry the bag with it.

What might this bag be called?

It might be called a *balloon.*

What is a balloon?

It is a bag filled with gas, and used for sailing in the air.

Fig. 19.

What is placed over this bag?

A network of ropes is placed over it, and they are so arranged as to extend beneath the bag, as is represented in Fig. 19.

What is fastened to these ropes?

A car or basket is fastened to these ropes.

What is the car or basket for?

It is to carry up those who wish to ascend with the balloon.

How large are balloons usually made?

They are from twenty to thirty feet in diameter.

With what are balloons filled?

Balloons are filled with a gas lighter than air.

What gas is often used for filling balloons?

The coal gas, such as is used to light our cities at night.

What lighter kind of gas is sometimes used?

Hydrogen gas is sometimes used.

Is hydrogen gas much lighter than the air?

It is so much lighter than the air, that fifteen cubic feet of hydrogen gas weigh no more than one cubic foot of air.

How much less will a balloon thirty feet in diameter weigh, when filled with hydrogen gas, than when filled with air?

It will weigh about ten thousand pounds less.

How much less, when filled with coal gas than when filled with air?

About two thousand pounds less.

How much force then is necessary to hold the balloon filled with coal gas to the earth?

A force of two thousand pounds, because the balloon is two thousand pounds lighter than the same bulk of air.

If a weight of only one thousand pounds were fastened to the balloon, what would result?

The balloon would rise in the air and carry the weight of one thousand pounds with it.

How high will the balloon ascend?

It will ascend until the air displaced is of the same weight as the balloon.

What will then become of the balloon?

It will be carried about in the currents of air.

With what is the car attached to the balloon loaded?

It is usually loaded with bags of sand, which serve as a weight to keep it from rising too high.

When those in the car wish to go higher, what do they do?

They throw the sand out, so as to lighten the car; then it will rise higher.

When they wish to descend, what do they do?

They open a valve at the top of the balloon, which permits some of the gas to escape; then it will sink towards the earth.

How is the valve at the top of the balloon opened and closed?

It is opened and closed by means of small ropes, reaching from the valve to the car beneath.

Can the balloon be made to go in any one direction?

No; it is carried about by the currents of air, and those in the car cannot control its course; therefore, it has never been of much use to man.

Winds.

What is wind?

Wind is air moving from one place to another.

Does the air move in every direction?

It does move in every direction, upward, downward, and to every side.

When the wind blows from the north towards the south, what is it called?

It is called a north wind.

What is it called, when it blows from other directions?

When it blows from the east, it is called an east wind; from the south, a south wind; and from the west, a west wind.

What causes the air to move from place to place?

Heat causes the air to move from place to place.

When air is heated, what change takes place?

The heated air ascends, and colder air moves in to fill its place; thus causing the wind to blow.

What illustration have we of this?

When a candle is held in the open door of a heated room, its flame is blown outwards if placed at the top of the door, and inwards if placed at the bottom of the door; thus showing two currents of air.

Why is this?

The heated air escapes from the top of the room, so as to ascend higher, while the colder air comes in at the bottom, to fill its place.

Why does the wind blow towards a fire in the open air?

Because the air near the fire becomes heated, and

ascends rapidly, so that the air rushes in from every direction to fill its place.

What does the earth do with the heat it receives from the sun?

The earth gives off its heat to the air nearest to it.

What becomes of this heated air?

This heated air ascends, and colder air comes to take its place; thus producing winds.

Are all parts of the earth heated alike by the sun?

No; they are not all heated alike.

How does this unequal heating affect the air?

It causes currents in the air all over the world.

Does water give off heat as rapidly as the earth does?

No; water is a poorer radiator of heat than the earth is.

On which will the air be the cooler when the sun shines, on the earth, or on the water?

It will be cooler on the water than on the earth.

Why does a sea-breeze feel cool in the daytime?

Because the air over the water, in the daytime, is less heated than the air over the land; hence, the sea-breeze feels cool.

Why does the earth become colder than the water at night?

Because the earth gives off its heat more rapidly than the water, and as it receives no heat from the sun at night, it soon becomes colder than the water.

Why does a land-breeze feel cool at night?

Because the air over the land at night is less heated than the air over the water; hence, the land-breeze feels cool.

How rapidly does the wind move?

A gentle breeze goes four or five miles in an hour; a high wind goes from twenty to fifty miles in an hour, and a hurricane goes from sixty to one hundred miles in an hour.

Of what use is the wind?

The wind carries away the impure air and injurious gases from cities and other places, so that they are the more healthy; it dries up the water on the surface of the earth, and thus promotes vegetation; it sweeps the clouds filled with moisture from the lakes and the oceans, over every part of the world, so that the water in them may fall in refreshing showers, to fill the springs, to purify the air, and in many other ways to make the earth a fitting place of abode for man. But these are only a few of the many blessings that an all-wise Creator has given us; and, for them all, we should ever remember to offer up to Him the homage of a grateful heart.

CHAPTER V.

WATER.

WHERE do we find water?

We find *water* almost everywhere; above the earth, on the earth, and beneath the earth's surface.

Where do we find water above the earth?

We find it in the air, in the form of vapor.

Where do we find water on the earth?

We find it in springs, in streams of water, and in lakes and oceans.

Where else is water on the earth?

It is in the sap of plants, the juice of fruits, and the blood of animals.

Where do we find water beneath the earth's surface?

We find it in streams running in every direction.

Has water any influence on climate?

Yes; water causes many changes in climate.

What changes does water produce in climate?

It makes spring and summer cooler, and autumn and winter warmer.

How does water make the Spring of the year cooler.

The ice and snow while melting, take up a large amount of heat, which passes into the water as latent heat.

Where does the melting ice and snow obtain this heat?

They obtain it from the air, and from objects near the surface of the earth.

What advantage is derived from this?

The tender buds and blossoms are kept back in the spring until the ice and the snow are melted, and the earth becomes warmed, so that they are seldom injured by the cold.

How does water make Summer cooler?

By the streams, lakes, and oceans, which absorb heat from the sun; and, as the water is a poor radiator, but little of this heat is given off to the air.

What effect does this heat produce upon the water?

The temperature of the water is gradually increased by it during the hot weather of summer.

How is this useful?

It gives heat to the plants in the water, so that they may grow; and it rouses into active life, the fish and other breathing things, from the torpid state in which they are during winter.

Does water store away a large amount of heat?

It does; and thus the summer is made much cooler.

How does water make Autumn warmer?

In the autumn the heat in the water is given off, so that the air is kept warmer than it would otherwise be.

How does this affect autumn weather?

It makes that season of the year mild and pleasant.

What advantage is derived from this?

It gives the late fruits and seeds a chance to ripen; and it affords time for the sap of plants to return to the roots, and to become prepared for the frosts of winter.

How does water make Winter warmer?

By being changed into ice and snow.

When water is changed into ice or snow, what takes place?

The latent heat in the water is given off, and thus the winter air is made warmer.

Can water be compressed into a smaller bulk?

Yes; it can be compressed, but not so much as air.

What is said of water that is compressed?

Its particles are pressed closer together, and it is said to be more dense.

Why is the water at the bottom of a pond more dense than that at the surface?

Because the water at the bottom of the pond has to bear the weight of all the water above it.

Is the weight of the water very great?

The weight of the water is very great.

What is its weight at the depth of one hundred feet?

At the depth of one hundred feet, it presses in every direction, with a force of forty-three pounds on every square inch of surface.

What is its weight in the ocean at the depth of one mile?

At the depth of one mile it presses in every direc-

tion, with a force of two thousand three hundred pounds on each square inch of surface.

When one opening is made near the top, and another near the bottom of a vessel full of water, from which will the water flow with the most force?

From the opening near the bottom of the vessel.

Why is this?

Because there is more weight of water to press it out from the opening near the bottom.

When water is poured into a vessel, what becomes of it?

It spreads out so that its surface is level.

Fig. 20.

When different vessels are connected together, what does the water do?

It falls to the same level in all of them.

How high will the tea stand in the spout of a tea-pot?

Just as high as the tea is in the tea-pot.

Will the tea in the spout balance that in the tea-pot?

The tea in the spout will balance that in the tea-pot, as is shown in Fig. 20.

How else can it be shown that water will rise to the same level in different vessels?

By a reference to Fig. 21, this may be seen.

Fig. 21.

Let these vessels be made so as to connect with each other by the tube at the bottom; then, when water is poured into one of them, it will rise up in each of the others, so as to be the same height in all.

Where is this principle used to benefit mankind?

It is used in supplying the inhabitants of cities with water.

What must be built in order to supply a city with water?

A reservoir must be built.

What is a reservoir?

It is a large basin made so as to hold water.

How high is the water in the basin?

It is usually as high as the tops of the houses in the city.

How is the water raised into the basin?

It is raised into the basin by means of pumps.

How is the water conveyed from the basin to the houses in the city?

By means of pipes laid under the surface of the earth, and extending to all parts of the city.

How high will the water rise in these pipes?

Nearly as high as it is in the basin.

If an opening be made in a pipe, how high will the water be forced up?

Nearly as high as the water in the basin.

What is the water flowing from such an opening called?

It is called a *fountain.*

What makes the water shoot up in a fountain?

The pressure of the water in the basin forces it to shoot up in the fountain.

To what does water always tend?

Water always tends to fall to a level.

What instrument is constructed on this principle?

The *water-level.*

What is a water-level?

It is a glass tube so nearly filled with water that it contains only a bubble of air. This tube is fastened in a piece of wood, as shown in Fig. 22.

Fig. 22.

How can we tell when the instrument is level?

By the bubble of air, which will always be at the centre of the tube when it is level.

What other liquid may be used to fill the tube?

Alcohol may be used to fill the tube, and it is then called a *spirit-level.*

Of what use is the spirit-level?

It is used for levelling the walls and wood-work of houses, bridges, and other structures.

Springs and Streams.

When we dig into the earth, can we always find water?

Yes; we can always find water.

What reason may be given for believing this?

Because thousands of wells have been dug in different parts of the country, and water is obtained from them.

Are these wells all of the same depth?

No; they vary in depth from four or five feet to eighty or ninety feet.

What makes the water *hard* in some wells?

When the stream of water passes through iron ore, before reaching the well, it absorbs some of the iron, which makes it hard.

How else may it become hard?

By passing through other mineral substances, such as limestone and sulphur, it will become hard.

Why is the water in some wells much warmer than in others?

In wells where the water is warm, the streams flowing into them are near the surface of the earth, and are heated by the sun; but in the wells of cold water, the streams are much deeper in the earth.

When these streams flow out at the surface of the earth, what are they called?

They are called *springs*.

Where are springs found?

They are mostly found on hill-sides, or in valleys; but they are sometimes found on the top of the hills.

Why is the water in some springs warmer than in others?

In springs where the water is warm, the streams flowing into them are so near the surface of the earth as to be warmed by the sun, while in springs where the water is colder, the streams are much deeper in the earth.

What becomes of the water in the springs?

It runs away down the valleys, forming *brooks* and *creeks*.

When these brooks and creeks flow into other brooks and creeks, what do they form?

They form *lakes* and *rivers.*

Into what do the rivers flow?

The rivers flow into the ocean.

How are waves produced?

Waves are produced by the winds blowing against the surface of the water.

What does a light wind produce?

A light wind produces only ripples on the surface of the water.

What does a stronger wind produce?

A stronger wind produces waves in the water.

Why is the water of the ocean and the larger lakes seldom at rest?

Because the wind touching the water seldom ceases to blow.

To what depth does the wind disturb the water of the ocean?

Wind seldom disturbs the ocean to a greater depth than thirty feet below its surface.

Fogs and Clouds.

What is always taking place from the surface of the water in the rivers, lakes, and oceans?

The water is always passing off in the form of vapor.

Where does this vapor go?

It goes into the air so that the air becomes filled with moisture.

What kind of air will hold the most vapor?

Warm air will hold the most vapor.

When warm air becomes colder, what is done with the vapor?

The vapor is condensed into small particles of water.

When this takes place near the earth, what does it produce?

It produces a *fog*.

Where do fogs mostly occur?

Fogs mostly occur over low grounds and along the course of streams.

When the vapor is condensed higher up in the air, what does it produce?

It produces a *cloud*.

What is a cloud?

A cloud is only a fog, higher up in the air.

Do fogs ever ascend in the air?

Yes; they often ascend, and thus produce clouds.

What causes the vapor of the air to be condensed into clouds?

Cold causes it to be condensed into clouds.

Does the air grow colder as we ascend?

Yes; the higher we ascend, the colder we find the atmosphere.

What becomes of the vapor in the air, as it ascends from the earth?

The vapor is condensed into clouds in the upper regions of the air.

Why do we mostly see clouds at the top of a mountain?

Because the vapor in the air is condensed into clouds by the cold at the top of the mountain.

When is a cloud formed in the air?

When a warm, damp wind meets with a cold wind, its vapor is condensed and a cloud is formed.

Are clouds often formed in this way?

Yes; clouds are often quickly formed in this way.

When the cloud passes into a warmer current of air, what becomes of it?

It is changed back into vapor, so that it cannot be seen.

How then can a cloud in the sky disappear very quickly?

By passing into a warmer current of air the cloud is changed into a vapor, and may thus quickly disappear.

Are clouds of different heights?

Yes; some clouds touch the earth, while other clouds are high up in the air.

Why are clouds higher on a fine day?

Because there is not so much moisture in the air, and, therefore, it rises higher before its vapor is condensed into clouds.

Why are clouds lower on a rainy day?

Because there is so much moisture in the air, that it is condensed into clouds near the earth.

Are the clouds high during a thunder-storm?

No; during a thunder-storm the clouds are seldom more than one-third of a mile high, and very often are much nearer the surface of the earth.

Is there any difference in the thickness of the clouds?

Yes; some are only a few inches thick, while others are a mile or more in thickness.

When the sun is about to rise, which of the seven colors of light is the first to appear?

The *red* color appears first.

When the sun sets, which of the seven colors is the last to fade away?

The *red* color is the last to fade away.

Why are the clouds red just before sunrise?

Because they are tinged by the red ray of light, before the other rays appear.

Why are the clouds red after sunset?

Because they are tinged by the red ray of light, after the other rays have faded away.

Dew.

What is dew?

Dew is the moisture that collects on plants and other objects, during the night.

What causes dew upon any object?

The air in contact with that object has its vapor condensed, so that the water is deposited on it in the form of dew.

Does the same quantity of dew collect upon all objects?

No; it collects much more upon some objects than upon others.

Upon what objects does it collect the most?

Upon those which radiate or give off heat the best.

Why do objects that are good radiators, collect the most dew?

Because they give off their heat rapidly after sunset, and before morning, become so cold that they condense the vapor in the air touching them, and cause the dew to be deposited on their surfaces.

What objects are the best radiators of heat?

Grass, wood, the leaves of plants, and, in fact, all things of a vegetable nature.

What objects then collect the most dew?

Plants collect the most dew.

Of what use is the dew to plants?

It supplies them with moisture, and answers in the place of rain.

When do we have the heaviest dew?

When the air is still and the sky is free from clouds.

Why does wind prevent the deposit of dew?

Because the air in contact with the grass and other objects, is removed so quickly that it does not get cool enough to deposit dew.

Why are dews heaviest when the air is still?

Because the air remains in contact with the grass and other objects, until it is cool enough to deposit the dew.

Why is there but little dew on a cloudy night?

Because the clouds prevent radiation of heat from the earth; hence, the earth and the objects near it, remain too warm to cause any dew.

Why is there a heavy dew on a clear night?

Because there is nothing then to prevent free radiation of heat from the earth; hence, it soon cools so as to cause a heavy dew.

How may dew be prevented from forming on any object?

By placing a cover over that object.

How does a cover prevent the formation of dew?

It prevents the object that is covered from giving off its heat, so that it does not get cool enough to cause a deposit of dew.

Why is there but little dew under trees?

Because trees prevent the free radiation of heat from the objects beneath them; hence, but little dew is formed under trees.

Why do stone walls *sweat*?

Because the walls cool the air in contact with them, so that its vapor is condensed into water, and deposited on the walls.

Why does the sweating of stones indicate rain?

Because it shows that the air contains a large amount of moisture.

When is a vessel of water said to sweat?

When drops of water collect on the outside of the vessel, it is said to sweat.

Why does a pitcher of cold water sweat?

Because the vapor in the air in contact with the cold pitcher is condensed into moisture, and deposited on the pitcher.

Why does the pitcher sweat most before a rain?

Because the air then contains a large quantity of moisture.

Why will not the pitcher sweat in fine weather?

Because the air contains only a small quantity of moisture in fine weather.

Why does moisture sometimes collect on a glass window in a warm room?

Because the glass cools the air, and causes its moisture to collect in small drops on the glass.

What makes the glass cold enough to condense the vapor in the air?

The cold air, outside of the room, in contact with the glass.

Where does the moisture in the air of the warm room come from?

It comes from the breath of persons, and from the steam of the tea-kettle.

When the breath is blown on a cold object, like a piece of glass or metal, what is the result?

The moisture in the breath is condensed by the cold object, and is collected in small drops of water on its surface.

Frost.

When the temperature of the air is reduced below thirty-two degrees, what becomes of the moisture collected on plants and other things?

The moisture is frozen.

What is this frozen moisture called?

It is called *frost.*

What then is frost?

Frost is the frozen moisture on the walls and window panes, and the frozen dew on plants and other objects.

On what objects do we find the most frost?

The most frost is found on objects having the most dew.

What is a heavy dew when frozen called?

It is called a hoar-frost.

When do we have a hoar-frost?

We have heavy frosts when the air is full of moisture.

Why does a heavy frost indicate rain or snow?

Because it shows that the air contains much moisture.

Are heavy frosts usually followed by rain or snow?

Yes; a heavy frost, on two successive mornings, is mostly followed by rain or snow within a few hours.

Rain, Snow, and Hail.

What is a *mist*?

A mist is very small drops of water falling through the air.

When these drops are larger, what is it called?

It is called *rain*.

What causes rain?

Rain is caused by the sudden cooling of the air above the earth.

How does cooling the air cause rain?

The cold condenses the vapor in the air, so that its moisture is forced out in drops, which fall to the earth.

What becomes of the rain falling upon the earth?

A part of it remains on the surface of the earth, and is either absorbed again by the air, or is carried away to the ocean by the creeks and rivers.

What becomes of the remaining part?

It sinks into the earth, to furnish moisture to the roots of plants, and to supply the streams beneath the earth's surface with water.

How does rain purify the air?

By washing away many things that would, if left, decay and make the air impure and unhealthy.

When the air is cooled below thirty-two degrees, what becomes of the moisture in it?

The moisture in it is frozen.

What is this frozen moisture in the air called?

It is called *snow*.

What are the particles of snow called?

They are called snow-flakes.

Are these snow-flakes all alike?

No; they vary very much in size and shape.

What does Fig. 23 represent?

It represents a few of the various and beautiful forms of the snow-flake or snow-crystals.

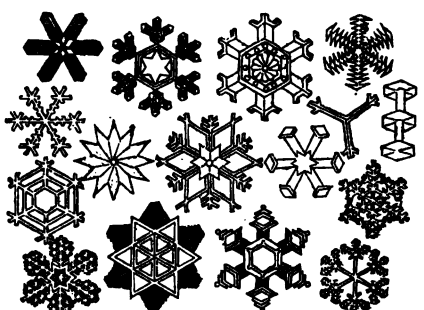


Fig. 23.

At what temperature of the air does snow usually fall?

At a temperature of about thirty-two degrees.

Is there any reason for the remark that it is "too cold to snow"?

Yes; for it seldom snows when the temperature of the air is much below thirty-two degrees.

Of what use is snow?

The snow is a warm covering for the earth.

Why is snow a warm covering for the earth?

Because the air in the snow makes it a poor con-

ductor of heat, so that it prevents the warmth of the earth from passing off into the air. Snow is, therefore, a protection to the plants, and prevents their being frozen by the cold weather of winter.

What is hail?

Drops of rain, when frozen, are called *hail.*

How is hail formed?

The rain-drops are frozen as they fall through the air; hence, the hail-stones of winter are no larger than the rain-drops.

When have we *dew?*

When the air in contact with the earth or the plants is cooled, its vapor is condensed into dew.

When have we *frost?*

When the air in contact with the earth or the plants is cooled below thirty-two degrees, its vapor is condensed into dew, and the dew is frozen into frost.

When have we *fog?*

When the air near the earth is slightly cooled, its vapor is condensed into fog.

When have we *clouds?*

When the air higher above the earth is slightly cooled, its vapor is condensed into clouds.

When have we *mist?*

When the air is a little more cooled, its vapor is condensed and mist falls.

When have we *rain?*

When the air is still more cooled, its vapor is condensed and rain falls.

When have we *snow*?

When the air is cooled below thirty-two degrees, its vapor is condensed and frozen into snow.

When have we *hail*?

When the rain-drops, while falling, pass through a current of air cold enough to freeze them, hail is produced.

Ice.

What is ice?

Ice is frozen water.

When does water freeze?

Water freezes when its temperature is reduced to thirty-two degrees.

Is water increased in bulk by freezing?

Water is increased in bulk by freezing.

Why do water-pipes often burst in cold weather?

The water in them freezes, and as it increases in bulk, the pipes burst.

Why are some springs never frozen?

Because water, much above the freezing-point, is always flowing into them from the earth, and thus they are kept too warm to freeze.

Why are some other springs frozen?

Because the water flowing into them comes from near the surface of the earth, and is soon made cold enough to freeze.

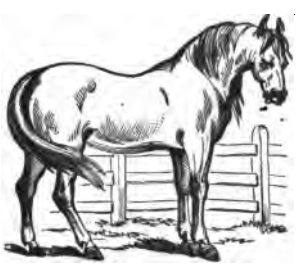
Does salt water freeze at the same temperature as fresh water?

No; fresh water freezes at thirty-two degrees, but

salt water requires a lower temperature depending upon the amount of salt it contains.

How is this useful?

The surface of the ocean is never frozen over except in very cold latitudes; hence, vessels may sail on it at all seasons of the year, and carry the products of one country to another; thus adding much to our comfort and our enjoyment.



CHAPTER VI.

SOUND.

WHEN the hands are brought quickly together, what is produced?

They produce a shaking or vibration in the air.

What is this vibration in the air called?

It is called a wave in the air.

What is this wave in the air like?

It is like a wave in the water.

When this wave in the air reaches the ear, what does it produce?

It produces a sensation which is called *sound.*

When a stone is dropped into the water, what does it produce?

It produces waves in the water.

How do these waves move?

They move in every direction from the stone.

Do they get smaller the farther they go?

They do get smaller and smaller, until at last they disappear.

Do the waves of sound in the air act in the same way as the waves in the water?

They do act in the same way.

What then becomes of the waves of sound?

They get smaller and smaller the farther they go, until at last there is no wave left.

When the wave in the air is large, what kind of sound is made?

It makes a loud sound.

As the wave gets smaller, does the sound grow fainter?

Yes; the smaller the wave the fainter the sound, until at last both the wave and the sound die away.

Where must we be to hear a loud sound?

We must be near the place in which the sound is made.

What kind of waves will make a faint sound?

Small waves in the air make a faint sound.

Will these waves extend as far away as larger ones?

No; as all waves of sound decrease in size as they recede, the smallest ones will soonest disappear.

Why will a loud sound be heard farther than a fainter sound?

Because the waves in the air from the loud sound will extend farther away than those from the fainter one.

How are sounds produced?

Sounds are produced by striking solid bodies together.

How else may sound be produced?

By striking a solid body against a liquid, as a stick struck against the water.

In what other way may sound be made?

Sound may be made by causing a substance to move rapidly through the air.

When a piece of wood attached to a string is swung rapidly around, what kind of a noise is made?

It makes a humming noise.

When lightning passes through the air, what noise is made?

A noise which we call thunder.

How can a murmur be produced?

When sounds, too faint to be heard separately, are united, they produce a murmur.

Where may we hear a murmur?

We may hear a murmur from the brook, as its waves flow over the pebbles, and from the wind, as it passes through the trees.

When a sound is heard but once, what is it called?

It is called a noise.

When sounds are made at irregular intervals, what are they called?

They are called noises.

When sounds are repeated at regular intervals, what do they become?

They become musical sounds.

Upon what do the high and low sounds in music depend?

They depend upon the rapidity with which the waves are produced in the air.

When the waves are repeated rapidly, what sound is made?

They make a high or acute sound.

When they are repeated more slowly, what sound is made?

They make a low or grave sound.

How small a number of vibrations or waves in the air can be heard?

Sixteen vibrations in a second of time, will produce the gravest sound that can be heard.

How large a number of vibrations in the air can be heard?

Twenty-four thousand vibrations in a second of time, make the most acute sound that can be heard.

How is the human voice made?

It is made by means of the vocal chords at the upper part of the larynx.

What is the larynx?

The upper part of the windpipe is called the larynx.

How do these chords produce the voice?

When the air is forced out of the lungs, it causes these chords to vibrate, so as to produce the voice.

Are these chords the same in all persons?

No; they are larger and coarser in some persons than in others.

In whom are they larger and coarser?

They are usually larger and coarser in men, and they are smaller and finer in women.

What kind of a voice is made by the large and coarse chords?

They make a rough, coarse voice.

What kind of voice is made by the finer chords?

They make a finer and more delicate voice.

Do these chords vibrate so rapidly in man as in woman?

No; they do not vibrate so rapidly in man as in woman.

What kind of voice do rapid vibrations make?

They make an acute voice; hence, woman can, when singing, raise her voice to a very high pitch.

Where is the sensation of sound produced?

The sensation of sound is produced on the ear.

Do people vary in their ability to hear?

Yes; they vary very much in their ability to hear.

Is every person able to distinguish musical sounds?

No; some persons cannot tell one musical note from another, and some cannot even tell one bird from another by its notes.

Is the hearing of all animals alike?

No; some can hear more acutely than others; a lion has more acute hearing than a man.

What other animals have acute hearing?

All such animals as hares, rabbits, and deer.

Of what use is the acute hearing to these animals?

It enables them quickly to hear the approach of their enemies, so that they may run away in time to escape the danger.

Conduction of Sound.

How does sound come to our ears?

Sound is carried to our ears by the air.

Is the air a conductor of sound?

Yes; the *air* is a *conductor* of sound.

Is there any sound where there is no air?

No; there is not any sound where there is no air.

How do we know this?

When a bell is rung in a vacuum, no sound is heard.

Can sounds be distinctly heard when the air is rare?

No; the rarer the air the more poorly it conducts sound.

What proof have we of this?

On the top of a high mountain the human voice is

heard only at a distance of a few yards; and a pistol when exploded sounds as faintly as the breaking of a stick.

Can sounds be heard better when the air is dense?

Yes; the denser the air, the better it conducts sound.

What proof have we of this?

The human voice sounds so distinctly in the dense air of deep mines, that conversation may be carried on in a whisper.

Why are sounds heard better at night than in the day?

Because the air at night is condensed by cold, and becomes a better conductor of sound; also, because the nights are stiller, and fewer sounds take our attention.

Why is moist or damp air a better conductor of sound than dry air?

Because the particles of water in the damp air increase its power of conduction.

Why is sound heard farther when over the water?

Because the damp air over the water is a better conductor, and because it contains fewer objects to obstruct the waves of sound.

How far has the human voice been heard over the water?

The words "all 's well" have been heard across the Strait of Gibraltar, a distance of *ten* miles.

How far has the human voice been heard over the land?

It has been heard at the distance of *four* miles.

How does the wind affect sound?

The wind carries the sound the way in which it is

blowing, so that a noise may be heard much farther with the wind than against it.

Why does water conduct sound faster than air?

Because the particles of water are closer together than the particles of air.

How can we prove that water is a conductor of sound?

When a bell is rung under water, the sound may be heard by any person whose head is beneath the surface of the water.

Does a solid substance conduct sound more rapidly than air?

It does, much more rapidly.

How can we prove this?

When the ear is placed at one end of a log of wood and the other end is struck with a hammer, two sounds will be heard; first, the one coming through the log, and, afterwards, the one coming through the air.

What use is made of this fact?

The tramping of horses or the rumbling of cars and wagons, when at a distance, may be heard by placing the ear near the ground.

Do all solid substances produce the same amount of sound when struck?

No; soft substances, such as lead and wood, produce but little sound; while hard substances, such as copper, bell-metal, and glass, produce much more sound.

What are hard bodies, producing much sound, called?

They are called *sonorous* bodies.

Is a bell a very sonorous body?

Yes; a bell is one of the most sonorous bodies that we have.

Why does a bell ring when struck?

Because the stroke causes the particles of the bell to vibrate.

When we touch a bell while ringing, why does the sound stop?

Because we stop its vibrations when we touch it.

Why does a crack in a bell check its ringing?

Because the crack stops the vibrations in the metal.

What other substances ring when struck?

All vessels made of glass, earth, stone, iron, etc., ring when struck.

How may we detect a crack in any such vessel?

By striking the vessel; if it is cracked there will be no ringing sound.

Trumpets and Speaking-Tubes.

How do the waves of sound move?

The waves of sound move in every direction from the place where the noise is made.

Why do we put both hands around the mouth when we call to a person at a distance from us?

We do so to keep the waves of sound more together.

Does it make the voice louder?

It does make the voice louder.

What instrument has been made so as to operate in the same way?

The *speaking-trumpet*, as is shown in Fig. 24.

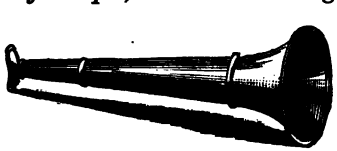


Fig. 24.

Of what use are speaking-trumpets?

They are of much use to firemen when giving orders at a fire, and to those on board of vessels when giving orders to the sailors.

Why do we hold the hand behind the ear when we wish to hear more distinctly?

Fig. 25.

Because the hand catches more of the waves of sound, and conducts them to the ear.

What instrument has been made to serve the same purpose?

The *ear-trumpet*, as is shown in Fig. 25.

How does the ear-trumpet aid the hearing?

The large end of the trumpet collects more of the waves of sound than the ear can; hence, more waves reach the ear.

Why do such animals as the horse, the rabbit, and the deer, hear better than we do?

Because their large ears act like ear-trumpets to collect the waves of sound, and thus increase their faculty of hearing.

How can these animals still farther increase their sense of hearing?

By being able to turn their ears, just as we do the ear-trumpet, in the direction whence the sound comes.

What are speaking-tubes?

They are metal pipes extending from one part of a building to another part.

Of what use are speaking-tubes?

They are used to convey the voice to the more distant parts of a building.

Do they require loud talking?

No; even a whisper has been heard through a metal pipe over three thousand feet long.

Velocity of Sound.

How fast do the waves of sound move through the air?

They move at the rate of ten hundred and ninety feet in a second of time, when the temperature of the air is thirty-two degrees.

What effect does warm air have on sound?

Sound travels more rapidly in warm air.

How much does heat increase the velocity of sound?

The velocity of sound is increased one foot in a second of time, for every degree of heat added to the air; so that sound travels eleven hundred and twenty feet in a second, when the temperature is at sixty-two degrees, which is nearly *one mile* in *five seconds.*

Does light travel more rapidly than sound?

Yes; light comes from the moon to the earth, a distance of two hundred and forty thousand miles, while sound moves eleven hundred and twenty feet.

What familiar examples of this difference may be given?

A wood-chopper's axe is seen to descend before we hear the stroke, and the smoke from a gun is seen before we hear the report.

How can we tell the distance of the wood-chopper from us?

If we count the number of seconds between the stroke of the axe and the time when the sound reaches our ear, and multiply eleven hundred and twenty by

this number, it will give us the distance in feet; because sound travels eleven hundred and twenty feet in a second.

How can we tell the distance of lightning from us?

If we count the number of seconds between the lightning and the thunder, and divide this number by five, it will give the distance in miles; because sound travels one mile in every five seconds.

How rapidly does sound travel through water?

Sound travels about *four* times as rapidly through *water* as it does through air.

How rapidly does sound travel through a solid?

Sound travels *ten* times as rapidly through *wood*, and *sixteen* times as rapidly through *glass*, as it does through air.

Does a loud sound travel more rapidly than a faint one?

No; it does not.

How do we know this?

Because the notes from a band of music come to us in the order in which they are played, whether they are loud or faint.

Reflection of Sound.

What becomes of the waves of sound when they strike a solid substance?

They are thrown back, as light from a looking-glass, or a ball from a stone wall.

What is this called?

It is called *reflection* of sound.

In what direction is sound reflected?

Sound, like light, is reflected so that the angles of incidence and reflection are always equal.

When the reflected sound comes back to the ear, what does it make?

It makes an *echo*.

When the sound comes back several times, what does it make?

It makes several echoes.

Where are echoes always to be heard?

Echoes may be heard in the deep caves of the earth; because the walls of the caves reflect sounds striking against them.

What curious echo may be mentioned?

There is an echo in Fairfax County, Virginia, which sends back twenty notes played on a flute.

Does every reflection of sound produce an echo?

No; it does not.

Why is there no echo from the walls of a small room?

Because the walls are too close together to make an echo.

How far away must the reflection of a sound be made, so as to produce a perfect echo?

Sound must be made not less than one hundred and twelve feet distant to produce a perfect echo.

How many syllables can be heard from an echo one hundred and twelve feet distant?

Only one syllable can be heard.

How far must the echo be to hear two syllables?

It must be twice the one hundred and twelve feet, or two hundred and twenty-four feet, to hear two syl-

lables; and three times that distance to hear three syllables, and so on.

Why can a person when speaking, be heard better in a room than in the open air?

Because the walls of the building reflect his voice to the hearers, so that more waves of sound reach their ears.

Why are noises heard so distinctly in an unfurnished dwelling?

Because there is then nothing but the walls to obstruct the waves of sound; but when the dwelling is furnished, each article of furniture helps to obstruct the sound and to make it less distinct.

What may be said of the harmony of sounds?

The babbling of the brook, the roaring of the cataract, the wailing of the wind, and the singing of the birds, everywhere show the Divine love of harmony; for where there is no human ear to listen, they still sing their heavenly anthems of praise to His ear alone.

CHAPTER VII.

MATTER.

IN what form is all matter found?

In the form of a solid, a liquid, or a gas.

What is true of all solids?

All solids must have length, breadth, and thickness.

Do solids vary much in length, breadth, and thickness?

Yes; they vary so much that we can scarcely find two things exactly alike in shape and size.

Can the shape of any substance be changed?

Yes; its shape may be changed in many ways.

What takes place in india-rubber when it is stretched?

Its particles are drawn farther apart, and its shape is altered.

When the force is removed, what does the india-rubber do?

It springs back into its former shape.

What is this property of the india-rubber called?

It is called *Elasticity*.

Can air be pressed into a smaller bulk?

It can, by means of a weight.

When the weight is removed, what does the air do?

The air goes back to its former bulk.

Is air very elastic?

Yes; air is one of the most elastic substances known.

Why does a ball rebound when thrown against the floor?

Because the substance of the ball is pressed out of shape when it strikes the floor, and, in its effort to spring back to its former shape, it is forced to rebound.

Why does the ball rebound from the floor?

Because the floor is firm, and will not move from the ball.

Does a ball rebound when it strikes a soft substance?

No; it does not rebound when it strikes a soft substance, like a heap of wool or feathers.

Are solids ever elastic?

Yes; many solids are elastic.

Name some articles useful from their elastic properties.

Watch-springs, wagon-springs, steel pens, and spring seats are very useful.

Why does a wooden bow throw an arrow from it?

When the force that bends the bow is removed, it springs back to its former shape, and in so doing throws the arrow from it.

Can metals be bent?

Yes; nearly all metals can be bent.

What is this property of being bent called?

It is called *Flexibility.*

Do substances usually spring back after being bent?

No; they usually remain in the bent form.

Can glass be bent?

Glass can be bent only a very little without being broken.

What is this property of being easily broken called?

It is called *Brittleness.*

What may be said of brittle substances?

Brittle substances are generally hard, while flexible substances are much softer.

What metal may be made either flexible or brittle?

Steel, when heated and cooled slowly, becomes flexible, but when cooled quickly, it becomes brittle.

For what is brittle steel used?

It is used for making knives, razors, axes, and other cutting instruments.

What may be done with metals that are flexible?

They may be hammered into thin plates.

What is this property in metals called?

It is called *Malleability.*

Which is the most malleable of all metals?

Gold is the most malleable; and it can be made into leaves so thin that three hundred and sixty thousand of them, when placed together, make a bulk only one inch in thickness.

Name some other metals that are malleable.

Silver, copper, tin, zinc, iron, and lead.

Can the particles of a piece of iron easily be separated?

No; its particles cannot easily be separated.

What is this property of iron called?

It is called *Tenacity.*

Can the particles of a brittle substance, like glass, easily be separated?

Yes; its particles can easily be separated.

Is there much tenacity in brittle substances?

No; there is very little tenacity in brittle substances.

Is there any tenacity in air?

No; because its particles are always trying to separate from each other.

Is there any tenacity in water?

Only a little, just enough to hold its particles together in the form of drops.

Upon what does the strength of substances depend?

Their strength depends upon their tenacity.

Do the different kinds of wood vary much in strength?

Yes; hickory and oak are much stronger than pine or cedar.

When is a knowledge of the strength of wood necessary?

It is necessary to know the strength of wood used in the construction of stores, bridges, houses, etc.

Which is the most tenacious of metals?

Iron is the most tenacious of metals.

How is this principle in iron made useful?

It is useful in the construction of suspension bridges, and in very many other ways.

Can iron be drawn into wire?

Yes; iron can be drawn into wire.

What is this property of being drawn into wire called?

It is called *Ductility*.

Which are the most ductile of metals?

Platinum, silver, iron, copper, and gold, are the most ductile, in the order named.

When is glass ductile?

When glass is melted it becomes ductile, and may be drawn into very fine threads.

If we take half the air out of a room, what will the remaining half do?

Its particles will separate until they fill the whole room.

What is said of air when its particles are thus separated?

The air is in a state of *rarity*.

What is said of it when the particles are pressed closer together?

The air is then said to be in a state of *density*.

Are the particles of water closer together than those of air?

Yes; therefore water is denser than air.

Upon what does the weight of a substance depend?

Its weight depends upon its density.

How much heavier is steel than water?

Steel is seven times as heavy as water, and is, therefore, seven times as dense.

How much denser is mercury than water?

Mercury is thirteen times as dense as water, and is, therefore, thirteen times as heavy.

Why can a bird move through the air?

Because the particles of air can be separated by the bird.

Why can a fish swim through the water?

Because the particles of water can be separated by the fish.

Why can a needle be passed through cloth?

Because the fibres of the cloth can be separated by the needle.

Why can a nail be driven through a board?

Because the fibres of wood can be separated by the nail.

What name is given to this property in these substances?

This property is called *Penetrability.*

What is necessary in order to penetrate a substance?

We must use a substance harder than the one which we wish to penetrate.

Why will iron penetrate wood?

Because iron is harder than wood.

Why cannot our bodies penetrate the wood?

Because our bodies are softer than the wood.

Why can our bodies move more easily through air than through water?

Because air is more easily penetrated than water.

Why can a nail be driven into a pine board more easily than into an oak board?

Because the fibres of pine are more easily separated than the fibres of oak; hence, pine wood is more penetrable than oak wood.

CHAPTER VIII.

ATTRACTION.

COHESION AND ADHESION.

WHY can a cup be lifted by taking hold of the handle?

Because the particles of the cup do not separate from each other.

What is the power which holds these particles together called?

It is called *Cohesion.*

In what bodies is cohesion the strongest?

Cohesion is strongest in solid bodies.

Is the cohesion alike in all solids?

No; the cohesion in iron is much greater than the cohesion in wood.

Upon what does the strength of a substance depend?

The strength of a substance depends upon the amount of cohesion among its particles.

What effect does heat have upon the cohesion of bodies?

Heat tends to destroy the cohesion of bodies by separating their particles.

How does heat affect ice?

Heat destroys the cohesion between the particles of ice, and thus it is changed into water.

How does heat affect water?

When still more heat is applied, the cohesion in the water is destroyed, and thus it is changed into steam.

Is there any cohesion in steam?

No; there is not any cohesion in steam.

Is there any cohesion in air?

No; because the particles of air are always trying to separate from each other.

Is there any cohesion in liquids?

Yes; there is some cohesion in liquids, but it is only strong enough to hold them together in drops.

Does the cohesion in liquids vary?

Yes; the cohesion in mercury is stronger than it is in water; therefore, a drop of mercury is larger than a drop of water.

How is it in chloroform?

The cohesion in chloroform is weaker than it is in water; therefore, a drop of chloroform is smaller than a drop of water.

How is shot made?

When lead is melted and poured through a sieve at the top of a high tower, the attraction of cohesion forms it into round drops or globules; these cool, while falling, thus forming the grains of shot.

How high must a shot-tower be?

A shot-tower must be not less than two hundred feet high, so that the lead may harden while falling.

Why does putty stick to a pane of glass?

Because there is an attraction between the putty and the glass.

What is this attraction called?

It is called *Adhesion.*

Upon what does adhesion depend?

Adhesion depends upon the attraction which substances have for each other.

Has water any attraction for oil?

No; therefore, there is no adhesion between oil and water.

Has glass any attraction for water?

Yes; therefore, the water collects on the glass in drops.

What other examples of adhesion may be given?

Paint adheres to wood, dust to furniture, and tin and mercury to the back of a looking-glass.

Will you name a few of the most adhesive substances?

Glue, mortar, paste, and putty.

Of what use is glue?

Glue fastens pieces of wood together.

Of what use is mortar?

Mortar fastens together the bricks and stones used in the construction of houses and other buildings.

Of what use is paste?

Paste fastens pieces of paper together, and it fastens paper to the walls and ceilings of rooms.

Of what use is putty?

Putty fastens the glass to the wood-work of our windows.

Capillary Attraction.

Why does a sponge suck up water?

Because the particles of the sponge have an attraction for the water.

What is this attraction called?

It is called *Capillary* attraction.

In what bodies do we find the most capillary attraction?

In those that are of a porous or spongy nature.

Why does a lump of sugar or salt, when partly dipped into water, soon become entirely wet?

Because sugar and salt are porous substances, and the water rises in them by capillary attraction.

Why does a heap of dry sand soon become damp when one edge touches the water?

Because the water is drawn through the sand by capillary attraction.

Why does water poured into the saucer of a flower-pot soon wet the earth in the flower-pot?

Because the earth is porous, and the water is drawn up through it by capillary attraction.

How does the oil in a lamp rise so as to be burned?

The oil is drawn up through the wick by capillary attraction.

Where may examples of capillary attraction be noticed?

In blotting-paper when it takes up the ink, and in bread when it soaks up the juice of meats.

What other examples may be given?

When one end of a towel is placed in a basin of water, and the other end is left hanging outside the

basin, the water will pass through the towel by capillary attraction, until the basin is entirely dry.

Why is water in a glass tumbler a little elevated at the edges?

Because the glass has a slight attraction for the water near it, and thus lifts it up a little.

Fig. 26.

Why will water rise in a small glass tube higher than in the surrounding vessel?

Because the glass has an attraction for the water, and elevates it at the edges, as is shown in Fig. 26.

Why do salt and other substances dissolve in water?

Because water overcomes the force of cohesion in the salt, and thus separates its particles. The capillary attraction between the salt and the water is greater than the cohesion between the particles of salt; hence, the salt is dissolved by the water.

Gravitation.

When a ball is thrown into the air, why does it fall back to the earth?

Because the earth attracts the ball.

Why do rain and snow fall to the earth?

Because the earth attracts them.

What is this kind of attraction called?

It is called attraction of *Gravitation.*

Does the attraction of gravitation exist in all things?

Yes; every substance attracts every other substance.

Upon what does the attraction of gravitation in a body depend?

It depends upon the size and weight of that body.

Do larger bodies attract with more force than smaller ones?

Yes; larger bodies do attract more than smaller ones.

Do heavy bodies attract with more force than light ones?

Yes; heavy bodies do attract more than light ones, although they may be of the same size.

Where are all substances drawn by the attraction of gravitation?

They are all drawn towards the centre of the earth.

Why are substances drawn towards the centre of the earth?

Because the earth is larger than any substance on or near its surface.

In what direction do all objects fall through the air?

They all fall towards the centre of the earth.

Which way then do we call "down"?

Down is always towards the centre of the earth.

Which way do we call "up"?

Up is always away from the centre of the earth.

Where must all plumb lines or perpendicular lines point?

They must all point with one end towards the centre of the earth.

When the earth turns over, can any substance fall away from its surface?

No; all things are drawn to the earth with so much force that they cannot fall away.

Upon what does the weight of a body depend?

The weight of a body depends upon the force with which it is drawn towards the earth.

What kind of substances are attracted with the most force?

Those that are the most dense, like the metals; hence, they are the heaviest.

What causes a liquid to form into a drop at the mouth of a bottle?

The attraction of cohesion causes the drop to be formed.

What causes the drop to fall to the earth?

The attraction of gravitation causes the drop to fall to the earth?

When water is poured from a tumbler, why does it run down the side of the tumbler?

Because the attraction of cohesion draws the water to the side of the tumbler, as is shown in Fig. 27.

Fig. 27.

Why does a spout prevent the water from running down the side of the vessel?

Because the spout is curved so that its lowest point is where the water falls from it; hence, gravitation causes the water to fall directly to the earth, as is shown in Fig. 28.

Fig. 28.

Does the air obstruct bodies when falling through it?

Yes; air obstructs all bodies when falling through it; but it obstructs light bodies more than heavy ones.

Do all bodies fall with equal rapidity in a vacuum?

Yes; all bodies fall with equal rapidity in a vacuum.

What bodies fall through the air most rapidly?

Those that are the heaviest or most dense; because they are the smallest in bulk.

Do heavy bodies increase in velocity as they descend?

They do increase rapidly in velocity as they descend.

How far does a heavy body like lead fall in one second?

It falls sixteen feet in one second.

A falling body increases thirty-two feet in velocity for every second of time it is in falling. During the first second it falls sixteen feet. During the second second, it falls sixteen feet plus thirty-two feet, or forty-eight feet. During the third second, it falls forty-eight feet plus thirty-two feet, or eighty feet, etc.

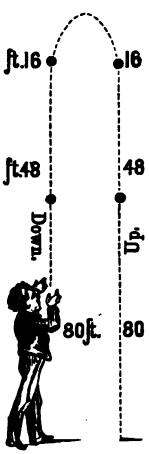


Fig. 29.

A rising body decreases thirty-two feet in velocity for every second of time it is in rising. If it be three seconds in rising, its velocity will be eighty feet the first second, forty-eight feet the second second, and sixteen feet the third second, being just the reverse of the same body when falling, as is shown in Fig. 29.

How may the distance a body falls in a given time be found?

It may be found by multiplying the number of seconds it is in falling, by the same number, and this product by sixteen feet. Thus, when it is three seconds in falling, multiply three by three, and this product by sixteen feet, which gives one hundred and forty-four feet, the distance it falls in three seconds.

What familiar example have we of the force of falling bodies?

We have an example in the large hail-stones which fall to the earth in summer-time, breaking the glass in our windows and doing much injury to the crops.

Centre of Gravity.

What is the centre of gravity in a body?

The *centre of gravity* in a body, is the point on which the body may be balanced, as is shown in Fig. 30.

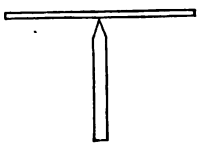


Fig 30.

Where is the centre of gravity in a circle?

It is the centre of the circle.

Where is the centre of gravity in a ball?

It is the centre of the ball.

What influence does the earth have on the centre of gravity?

The earth draws the centre of gravity in a body as near to itself as possible.

Why will an egg, when placed on either end, fall over on its side?

Because the centre of gravity is nearer the earth when the egg is placed upon its side than when upon either end, as is shown in Fig. 31 and Fig. 32.

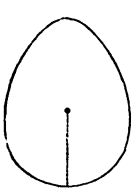


Fig. 31.

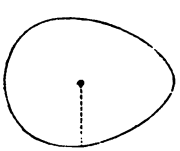


Fig. 32.

Why will a ball remain in any position when placed on the earth?

Because its centre of gravity is always the same distance from the earth, whatever may be its position.

When will a body change its position if left unsupported?

A body will change its position whenever by so doing its centre of gravity will be lowered.

When may a body be readily moved about?

When its centre of gravity always remains at the same distance from the earth while being moved.

Why is a round body, like a ball, easily rolled about the floor?

Because its centre of gravity remains at the same distance from the floor.

When is the position of a body difficult to change?

Whenever the centre of gravity in it has to be lifted up in order to make the change, as is shown in Fig. 35.

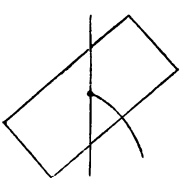


Fig. 33.

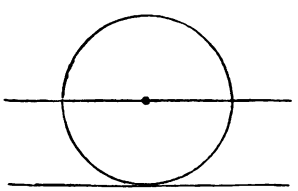


Fig. 34.

The centre of gravity, in Fig. 33, may be lowered; hence, it will change its position if unsupported. The centre of gravity, in Fig. 34, can neither be lowered nor lifted up; hence, it may be readily rolled about. The centre of gravity, in Fig. 35, must be lifted up; hence, it remains firm in its place.

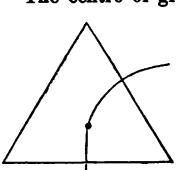


Fig. 35.

When does an object stand firm?

It stands firm when it has a broad base, and its centre of gravity is near the earth.

What effect is produced by elevating the centre of gravity?

The higher the centre of gravity in any body is raised above the earth, the greater is its tendency to fall.

Why is a load of hay more easily overturned than a load of iron, when upon the same wagon?

Because the centre of gravity in the load of hay is much higher than it is in the load of iron.

Why do passengers on top of a stage cause it to overturn more easily?

Because their weight on the top raises the centre of gravity in the stage, and it is more readily overturned.

Why is a person more likely to fall when standing up than when sitting down?

Because the centre of gravity is higher in a person when standing than when sitting.

Why is a boy more likely to fall when raised on stilts?

Because the centre of gravity in the boy is farther from the earth when he is raised on stilts.

When will a load of hay be overturned?

It will be overturned whenever the line from the centre of gravity to the earth falls outside of the wheels, as is shown in Fig. 36.

Fig. 36.

Why should lamps have large bottoms?

Lamps should have large bottoms so that the line of gravity may not fall outside of the bottom.

Where must the line of gravity in a body always fall?

It must always fall within the base of that body, or the body will be overturned.

How must a leaning tower be built so as not to fall?

It must be built so that the line of gravity will fall within its base.

Why do we lean back when carrying a load in front of us?

We lean back so that the line of gravity may be kept directly over our feet.

Why does a person standing up in a wagon fall when the wagon is suddenly moved?

Because the feet, being in contact with the wagon, move with it before the motion extends to the rest of the body, thus throwing the line of gravity behind the feet; hence, the person must fall, unless supported.

Why does a person standing up in a wagon fall when the wagon is suddenly stopped?

Because the feet, being in contact with the wagon, are suddenly stopped, while the body still moves forward, thus throwing the line of gravity ahead of the feet; hence, the person must fall, unless supported.

Why do animals with *four* feet stand firmer than those with only *two* feet?

Because the four feet afford a larger base to stand upon than the two feet do, and, therefore, support the centre of gravity better.

Why can a horse or a cow remain standing for many hours without seeming to be weary?

Because their four feet afford a good support to the centre of gravity.

Why does a person who is standing soon become weary?

Because it requires a constant effort to keep the line of gravity over the feet, and this soon produces weariness.

Why can a person sit longer than he can stand?

Because the centre of gravity is lower, when he is sitting, than when he is standing; hence, it requires less strength to support the body in a sitting position.

Why can a person lie down longer than he can sit or stand?

Because the centre of gravity is nearest the earth when he is lying down, and it requires no effort to remain in that position.

How do we measure time?

We measure time by means of a *pendulum*, such as is used in a common clock.

How does the pendulum move?

The pendulum moves regularly to and fro, from the line of gravity.

Does the pendulum vary any in its vibrations, or the time of moving to and fro?

The pendulum does not vary any in its vibrations.

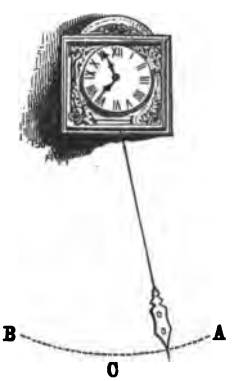


Fig. 37.

Why does the pendulum keep moving?

When the pendulum is at A, in Fig. 37, gravity causes it to descend to C, and the motion it gains while falling to C carries it up to B; gravity then causes it to descend to C, and the

motion it gains while falling to C carries it back to A again.

What helps to keep the pendulum in motion?

The works inside of the clock help to keep the pendulum in motion.

How long must the pendulum be, so as to tick once in every second?

The pendulum must be thirty-nine inches long.

How does it tick when the pendulum is *shortened*?

It ticks more *rapidly*.

How does it tick when the pendulum is *lengthened*?

It ticks more *slowly*.

How then does *cold* affect a clock?

Cold makes the clock go faster by shortening the pendulum.

How does *heat* affect a clock?

Heat makes the clock go more slowly by lengthening the pendulum.

How may the pendulum always be kept of the same length?

By having the weight at the bottom of the pendulum, so that it may be raised or lowered by means of a screw.

Specific Gravity.

Upon what does the weight of a body, when in the air, depend?

The weight of a body depends upon the force with which it is drawn towards the earth.

What is this attractive force called?

It is called gravitation or gravity.

What is gravity?

Gravity is the weight of any body.

What is specific gravity?

Specific Gravity is the weight of any body, compared with an equal bulk of water.

Do substances weigh as much in water as they do in air?

No; they do not weigh so much.

When we drop lead in a vessel full of water, what becomes of the water?

The water is forced over the sides of the vessel.

How much water is thus forced over the sides of the vessel?

A quantity equal in bulk to the lead dropped into the vessel.

When the water thus displaced weighs just one pound, how much less will the lead weigh while in the water than it did in the air?

It will weigh one pound less.

Then how much less is the weight of a body in water than it is in air?

Its weight in the water is as much less as the weight of the water which it displaces.

When a body has greater specific gravity than water, what will it do?

It will sink in the water.

When it has less specific gravity than water, what will it do?

It will float on the surface of the water.

Will all parts of the body be above the surface of the water?

No; a part of it will sink into the water.

How much of it will sink into the water?

It will sink so as to displace water enough to balance its own weight.

Why does a boat float on the water?

Because it weighs less than a bulk of water of the same size as the boat.

When a cargo is placed on the boat, why does it still float?

Because it still weighs less than a bulk of water of the same size as the boat.

How do we make use of this principle?

We make use of it in the construction of vessels, so as to carry on trade with other parts of the world.

Why can ducks and geese float on the water?

Because their light, downy feathers make their specific gravity less than that of the water; hence, they must float on its surface.

What may be said of the specific gravity of the human body?

When the lungs are filled with air, the specific gravity of the human body is rather less than that of water.

Can a person float in the water?

Yes; if a person, who cannot swim, will throw his head back so that his mouth and nose only remain above the water, he may float in this position for some time.

What is the specific gravity of fish?

The specific gravity of fish is so nearly equal to that of water, that they can move about anywhere beneath its surface.

How do fish rise and sink in the water?

Fish rise and sink in the water by means of an air-bladder in their bodies.

How does the air-bladder help the fish to rise or sink?

When the bladder is filled with air, the specific gravity of the fish becomes lighter, and it rises towards the surface; and when the air is forced out, the specific gravity becomes heavier, and the fish sinks towards the bottom.

Why does cream rise to the surface of milk?

Because the specific gravity of the cream is less than that of the milk.

Why does oil float on water?

Because the specific gravity of the oil is less than that of the water.

Why can a fat person float more easily in the water than a lean person?

Because the fat reduces the specific gravity of the body, so that it floats more easily.

Why can a person float more easily in salt water than in fresh water?

Because salt increases the weight of the water, and, therefore, it buoys up with more force.

What familiar example have we of this?

An egg will sink when placed in fresh water; but if salt be dissolved in the water, the egg will float near the surface.

CHAPTER IX.

MOTION.

WHEN is a body said to be in motion?

A body is in *motion* when it is moving from one place to another.

When is a body said to be at rest?

A body is at rest when it is not moving from one place to another.

What is necessary to give motion to a body?

Force of some kind is necessary to give motion to a body.

How long will the motion given to a body continue?

The motion will continue until it is checked.

What is necessary to check the motion of a body?

Force of some kind is necessary to check its motion.

What force is always acting so as to bring bodies to a state of rest?

The force of gravity, which is constantly drawing all bodies to the earth.

What else may check the motion of a body?

The air, the water, and solids of all kinds may check the motion of a body.

In what direction will a body move when its course is not obstructed?

It will move in a straight line.

Why does a ball struck by a bat make a curve to the earth?

Because the force of gravity gradually overcomes the force given by the bat, so that the ball moves in a curve.

Why does a bullet make a curve to the earth?

Because the force of gravity gradually overcomes the force given by the powder, so that the bullet moves in a curve to the earth.

When a person aims directly at a mark some distance from him, where will the bullet strike?

The bullet will strike below the mark.

Why will the bullet strike below the mark?

Because the force of gravity draws it towards the earth, while it is going from the gun to the mark.

When a ball attached to a string is whirled around, as in Fig. 38, what is the tendency of the ball?

The tendency of the ball is to fly off in a straight line.

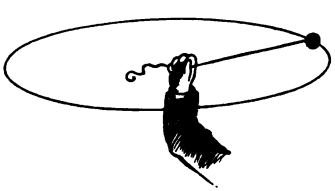


Fig. 38.

What is the force tending to make the ball fly off called?

It is called *centrifugal* force.

What keeps the ball from flying off?

The string keeps the ball from flying off.

What is the force exerted by the string called?

It is called *centripetal* force.

What then is centrifugal force?

It is the force tending to fly off from the centre.

What is centripetal force?

It is the force tending to draw towards the centre.

Why does mud fly off from the wheel of a wagon when in motion?

Because the motion of the wheel gives centrifugal force to the mud, and causes it to fly off.

What does the rim of a wheel when in motion, tend to do?

The rim tends to fly off from the centre of the wheel.

How is it prevented from flying off?

It is prevented by making the wheel very strong, so that all parts of it are held firmly together.

What does this centrifugal force sometimes cause?

The centrifugal force is so great that it sometimes causes grind-stones and mill-stones, when revolving rapidly, to burst into pieces.

What becomes of these stones when they burst?

When they burst, their pieces fly off in different directions, doing more or less injury to whatever obstructs their course.

When a horse turns a corner, why does the rider lean in the direction in which the horse is turning?

He leans so as to overcome the centrifugal force, and is thus prevented from falling off the horse.

How are cars prevented from running off the track, while turning a curve?

The outer rail is made higher than the inner rail, so as to overcome the tendency of the cars to run off the track.

What grand example have we of the action of these two forces?

The earth and other planets that move around the sun, are kept in their places by the action of these two forces.

When a ball strikes a solid body and bounds back, what is that motion called?

It is called *reflected* motion.

At what angle does the ball leave the solid body?

It bounds off from the solid body, so that the angle of reflection is always equal to the angle of incidence, as is shown in Fig. 39.

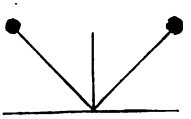


Fig. 39.

How may a stone be skipped on a smooth pond?

A stone may be skipped, by throwing it so obliquely that the water will cause it to bound off from its surface.

When a boat moves across a river at the rate of four miles an hour, and the current runs four miles an hour, in what direction will the boat go?

The boat will go diagonally across the river.

Why will the boat go diagonally across the river?

Because the boat will be carried as far down the river as the river is wide. If the river be one mile wide, then the boat, while crossing, will be carried down it one mile.

How do boatmen overcome this difficulty?

They overcome this by rowing the boat towards a point higher up the stream.

Does it take longer to cross a stream when the current is strong?

Yes; because the boat is carried farther down the stream by the current, and it must, therefore, go a greater distance in crossing.

Why is a person apt to fall when he jumps from a wagon that is moving?

Because his body partakes of the motion of the wagon and moves on after his feet are stopped by the ground, so that he falls forwards.

How can he prevent falling?

He can prevent falling by jumping in the same direction as that in which the wagon is moving.

When a stone is dropped from the top of a mast of a vessel, where does it fall?

The stone falls at the bottom of the mast.

Why does the stone fall at the bottom of the mast?

Because it partakes of the motion of the vessel, and is carried forward while falling.

When a ball is thrown perpendicularly into the air by a person on a boat, where does the ball fall?

The ball falls back into the person's hand, although the boat may have carried him several feet while the ball was in the air.

Why does the ball fall back into his hand?

Because it partakes of the motion of the boat, and moves as far as the boat moves.

When a stone thrown from a car is aimed at a post, where will it strike?

The stone will strike ahead of the post.

How far ahead of the post will the stone strike?

It will strike as far ahead as the car moves while the stone is going to the post.

Where must we aim so as to hit a bird that is flying?

We must aim ahead of the bird.

Why must we aim ahead of the bird?

Because the bird will move a short distance through the air while the shot is reaching it.

When a body in motion strikes one at rest, is the force felt alike by both bodies?

The force is felt alike by both bodies; thus, when one head is struck against another, both are equally hurt.

Do bodies, when moving rapidly, strike with more force than when moving slowly?

Yes; the force with which they strike depends upon their velocity.

What examples of this force may be given?

A nail may be driven into a board by a hammer, when it falls rapidly upon the nail; a bullet may be shot through a plank; and even a tallow candle, when shot from a gun, may move with velocity enough to pass through a pine board.

Why do large bodies start slowly?

Because it takes some time for the force to reach all parts of them.

Why is it difficult for horses to start a loaded wagon?

Because they must pull some time before the force reaches all parts of the wagon, causing it to move.

Why is machinery slow at starting?

Because it requires time for the force applied to reach all parts of the machinery.

When two solid bodies, moving slowly, strike against each other, what takes place?

They are pushed off from each other in opposite directions.

Which body is pushed off the more rapidly?

The one having the less weight, is pushed off the more rapidly.

When the oars of a boat push against the water, what takes place?

The boat and the water move in opposite directions.

When the wings of a bird strike the air, what takes place?

The bird and the air move in opposite directions.

How can a duck or a goose swim in the water?

The toes of a duck or a goose are joined together by a web which makes the foot broad, like a paddle; and when these broad feet are pressed against the water, the duck or the goose moves forward.

Can all birds swim in the water?

No; only those birds can swim whose toes are joined together by a web, thus giving them a broad foot to be pushed against the water.

What is produced by the rubbing of bodies together?

Friction is produced by rubbing bodies together.

What does friction tend to do?

Friction tends to check the motion of bodies.

How do we lessen the friction in machinery?

We lessen the friction in machinery by oiling the parts where they rub together.

How are waves produced in the water?

Waves are produced by the friction of the air upon the water?

What causes the water to flow in creeks and rivers?

The attraction of gravitation, which causes water always to fall to its lowest level.

What retards the current of water in streams?

The friction, caused by the water rubbing against the banks and bottoms of the streams, retards their current.

In what part of a stream is the current the strongest?

It is strongest in the middle of a stream, because there is less friction there.

What retards the flow of water through a pipe?

The friction of the water against the sides of the pipe, retards its flow very much.

Why do sudden turns in a pipe check the flow of water through it?

Because every turn in the pipe increases the friction made by the water.

Why does a wagon-wheel turn around when the wagon moves?

Because the friction between the wheel and the earth, prevents the wheel from sliding along.

Why can a steam-engine draw a train of heavy cars?

Because the friction, between the wheels and the rails, causes the wheels to turn around instead of sliding; and thus the engine moves forward drawing the cars with it.

Why is sand sometimes put on the rails?

Sand is put on the rails to increase the friction be-

tween the wheels and the rails, so that the engine may start a heavier train.

Why do we use sleighs when there is snow on the ground?

Because sleighs slip easily on the snow.

Why do sleighs slip easily on the snow?

Because there is but little friction between the sleigh and the snow.

Why do wagons run more heavily when the ground is soft?

Because their wheels then sink farther into the earth, and thus the friction is increased.

Why do wagons run more heavily when the ground is covered with snow?

Because their wheels sink into the snow, and thus the friction is increased.

Why will a person slip down upon the ice more easily than upon the earth?

Because there is less friction between his feet and the ice than there is between his feet and the earth.

Why do we put ashes on our walks when they are covered with ice?

We put ashes on our walks to increase the friction between the ice and our feet, so that we may not slip down when walking on them.

Why is a lock or a brake used on a wagon?

It is used to check the motion of the wagon.

How does a lock check the motion of the wagon?

The lock is pressed against the wheels, so that enough friction is produced to check the motion of the wagon.

Why does it require more force to draw a rusty plough through the ground, than to draw one that is bright and smooth?

Because the rust increases the friction between the plough and the ground, and this makes more force necessary in order to move it.

Why cannot we hold a live eel in our hand, as easily as we can a live fish?

Because the skin of the eel is so smooth, that there is much less friction between it and our hand, than there is between the fish and our hand. Dry sand or dry ashes sprinkled on the eel will increase the friction so that it can be held.

CHAPTER X.

MECHANICAL POWERS.

LEVER.

WHAT is a lever?

A *Lever* is a rod or bar of some kind used for raising weights.

Of what are levers made?

Levers are made of any solid substance, such as wood and iron.

When a spoon is balanced on a cup, as in Fig. 40, what may the spoon be called?

Fig. 40.

The spoon may then be called a lever.

Upon what does the spoon rest?

It rests upon the edge of the cup.

What is the cup on which the spoon rests called?

It is called a *Fulcrum.*

What is a fulcrum?

A fulcrum is any solid body against which a lever rests.

When the spoon is called a lever, what are the parts on each side of the fulcrum called?

They are called the *arms* of the lever.

What is necessary, so that a lever may balance?

The arms of the lever must be of equal weight, or they will not balance.

If the bowl of the spoon be filled with water, what will result?

The bowl will sink, and the handle of the spoon will rise.

What will cause the bowl of the spoon to sink?

The weight of the water in it will cause it to sink.

How can the bowl of the spoon be prevented from sinking?

By applying a force to the handle of the spoon, equal to the weight of the water put in the bowl.

What is the force applied to the handle called?

It is called the *Power*.

What three things are always necessary when the lever is used?

The *power*, the *fulcrum*, and the *weight*, are always necessary when the lever is used.

Which of these three things are movable?

The power and the weight are movable.

Which one does not move?

The fulcrum does not move.

How many kinds of levers are there?

There are three kinds of levers.

What is the first kind of lever?

It is where the fulcrum is between the power and the weight, as is shown in Fig. 41.

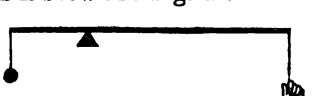


Fig. 41.

When the fulcrum is under the middle of the lever, how can the lever be kept balanced?

The lever will remain balanced, so long as the power and the weight used are equal to each other.

When the lever is moved, so that the fulcrum is nearer the weight, which arm of the lever is the heavier?

The arm towards the power, because it is the longer arm.

Will the power applied to the long arm of the lever be as heavy as the weight?

No; the nearer the fulcrum is to the weight, the less will be the power needed to balance that weight.

How will it be when the fulcrum is nearer to the power than it is to the weight?

Then the power must be heavier than the weight.

When the long arm of the lever is twice the length of the short arm, what will be the difference in the weights?

One pound applied to the long arm will then balance two pounds applied to the short arm.

Upon what does the power of a lever depend?

It depends upon how much nearer the fulcrum is placed to one end of the lever, than to the other end.

Of what use is the lever?

It is very useful in raising heavy bodies.

Fig. 42.

What is the weight to be lifted in Fig. 42?

The stone is the weight to be lifted.

Where is the fulcrum placed?

The fulcrum is placed near the stone.

Where is the power applied?

The power is applied by the hand to the long arm of the lever.

How may a see-saw be made?

A see-saw may be made by placing a plank or a board across a rail in a fence, so that it will balance.

Is the see-saw, as shown in Fig. 43, an example of the lever?

Yes; the see-saw is an example of the lever.

Fig. 43.

What are the parts of the plank on each side of the fence-rail called?

They are called the arms of the lever.

What is the fulcrum in the see-saw?

The fence-rail on which it rests, is the fulcrum.

What is the power in the see-saw?

The power is the boy on one end of the lever.

What is the weight in the see-saw?

The weight is the boy on the other end of the lever.

How do children play at see-saw?

By pushing against the earth with their feet, the arms of the lever are alternately forced to rise and fall in the air, thus making a see-saw.

Where must the fulcrum be when the two boys are of the same weight?

The fulcrum must be under the middle of the lever.

Where must the fulcrum be when one boy is heavier than the other?

The fulcrum must then be nearest to the heavier boy, so that they may balance.

Does it require much force to play at see-saw?

No; when the see-saw is balanced, a very little force will cause it to move up and down.

Of what use is a pair of scales?

A pair of scales is very useful in weighing different substances.

Fig. 44.

Are the scales, as shown in Fig. 44, an example of the lever?

The scales are an example of the lever.

Where is the fulcrum of the scales?

The fulcrum is the point on which the lever rests.

What is the weight?

The weight is the lead put in one scale.

What is the power?

The power is the substance put in the other scale, so as to balance the weight.

When the lead put in one scale weighs exactly a pound, how much sugar must be put in the other scale to balance the lead?

Exactly one pound of sugar must be put in to balance the lead.

For what is a balance mostly used?

A balance is mostly used for weighing heavy bodies.

Is the balance a lever?

Yes; the balance is a lever.

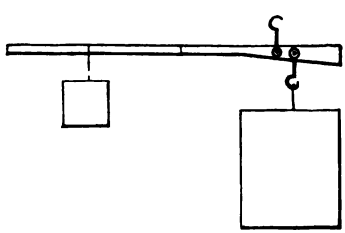


Fig. 45.

Which is the fulcrum in the balance?

The fulcrum is the hook that holds the balance up.

What is the weight?

The weight is the large body hanging from the short arm of the lever.

What is the power?

The power is the smaller body hanging from the long arm of the lever.

In Fig. 45, the distance from the fulcrum to the power is ten times the distance from the fulcrum to the weight; now, if the small body weighs one pound, how much must the large body weigh, so as to balance it?

The large body must weigh ten pounds.

When the small body weighs ten pounds, how much must the large body weigh, so as to balance it?

The large body must weigh ten times as much, or one hundred pounds.

If the smaller body be moved half-way to the fulcrum, how much weight will then balance it?

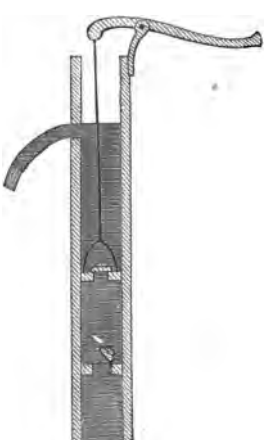


Fig. 46.

It will then take only half the weight, or fifty pounds to balance it.

What other familiar example of this kind of lever may be mentioned?

The pump-handle is a lever of this kind.

What is the power?

The power is the force applied to the pump-handle.

What is the fulcrum?

The fulcrum is the screw that fastens the handle to the pump.

What is the weight?

The weight is the water raised by the bucket.

Are scissors an example of the lever?

Yes; scissors are a double lever.

What is the fulcrum in the scissors?

The fulcrum is the rivet which holds the two levers together.

What is the power?

The power is the force applied by the fingers.

What is the weight?

The weight is the paper, or other substance, to be cut by the scissors.

Can scissors be made very strong?

Yes; some scissors are made so strong that they are used for cutting iron, tin, and zinc.

What other useful instruments are made upon the same principle as the scissors?

Such instruments as nippers, pincers, tweezers, and blacksmith's tongs.

What is the second kind of lever?

It is where the weight is between the power and the fulcrum, as is shown in Fig. 47.

Fig. 47.

Of what use is this kind of lever?

It is very useful in lifting heavy weights a short distance from the earth.

What example is there of this kind of lever?

The door on its hinges is a lever of this kind.

What is the fulcrum?

The hinges are the fulcrum.

What is the weight?

The door is the weight.

What is the power?

The force that opens or shuts the door is the power.

What other examples of this kind of lever have we?

We have an example in the lid of the tea-kettle, and in the cover of the ink-stand, when they are fastened on by hinges.

What is the third kind of lever?

It is where the power is between the fulcrum and the weight, as is shown in Fig. 48.

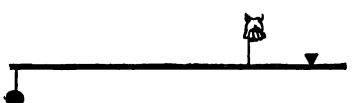


Fig. 48.

What examples of this kind of lever have we in common use?

The shovel, the spade, and the pitch-fork, are levers of this kind.

What is the fulcrum?

One hand is the fulcrum.

What is the power?

The other hand is the power.

What is the weight?

The earth raised on the shovel is the weight.

What other familiar example have we of this kind of lever?

The fishing-rod is an example of this kind. One hand is the fulcrum, the other hand is the power, and the line, with the fish, is the weight. This is made

Fig. 49.

plain by Fig. 49, representing a lad just drawing a fish out of the water.

There are several other examples of this kind of lever; will you name some of them?

Yes; brooms, hoes, rakes, and axes are all levers of this kind.

What is the first kind of lever mentioned?

It is where the fulcrum is between the power and the weight, as in Fig. 50.

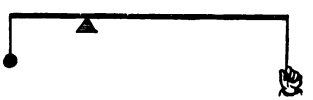


Fig. 50.

What is the second kind of lever mentioned?

It is where the weight is between the power and the fulcrum, as in Fig. 51.

Fig. 51.

What is the third kind of lever mentioned?

It is where the power is between the fulcrum and the weight, as in Fig. 52.

Fig. 52.

Wheel and Axle.

What other way have we for raising weights?

We have the *wheel and axle*, as is shown in Fig. 53.

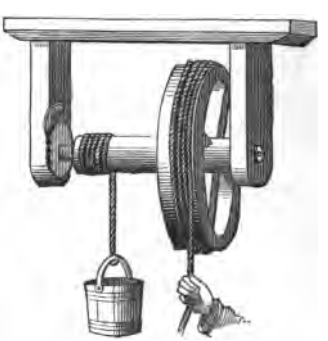


Fig. 53.

What is the wheel and axle?

The wheel and axle is only another form of the lever.

Where is the power applied?

The power is applied to the rope which passes around the wheel.

Where is the weight?

The weight is the bucket attached to the rope which passes around the axle.

Where is the fulcrum?

The fulcrum is the frame on which the ends of the axle rest.

Is the power applied to the wheel equal to the weight to be raised?

No; the power is always less than the weight to be raised.

Upon what do the power and the weight depend?

They depend upon the size of the wheel and the axle.

When the diameter of the wheel is ten times the diameter of the axle, how much will one pound raise?

One pound applied to the wheel, will then raise ten pounds on the axle.

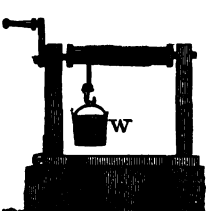


Fig. 54.

What is a windlass?

A *windlass* is another form of the wheel and axle, as is shown in Fig. 54.

What is used in a windlass in place of the wheel?

A crank or handle is used in place of the wheel.

Does the crank take the place of the wheel?

Yes; when the crank is turned, it forms a circle the same as the outside of the wheel.

To what use is the windlass often applied?

The windlass is often used to draw water from wells.

Pulley.

What is a pulley?

A *pulley* is a wheel with a groove or hollow cut in its edge.

What is the groove for?

The groove is cut so that a rope may move over the wheel without slipping off.

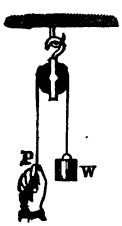


Fig. 55.

In Fig. 55, where is the power applied?

The power is applied to one end of the rope by the hand.

Where is the weight?

The weight is attached to the other end of the rope.

When the power and the weight are equal, what do they do?

They balance each other, and neither of them will move.

When the power is greater than the weight, what takes place?

The weight is then lifted up.

Of what use is the single pulley?

The single pulley is used for hoisting flags to the top of high poles, for raising sails to the topmasts

of vessels, and for raising weights to the upper stories of mills and factories.

How many pulleys are needed, when a horse is to raise the weight?

When a horse is to raise the weight, two pulleys are needed, as may be seen in Fig. 56.

Fig. 56.

To what use do farmers apply the pulley?

They arrange the pulleys so as to lift the hay into their barns, by means of a horse; thus saving themselves much hard labor.

Inclined Plane.

When one end of a plank is raised up, while the other end remains on the floor, is its surface level?

No; its surface is not level.

What may the surface of the plank be called?

It may be called an inclined surface, or an *inclined plane.*

What is an inclined plane?

An inclined plane is a surface that inclines upwards or downwards.

Of what use is the inclined plane?

It aids very much in raising weights.

Are all planes inclined alike?

No; some planes are much steeper than others.

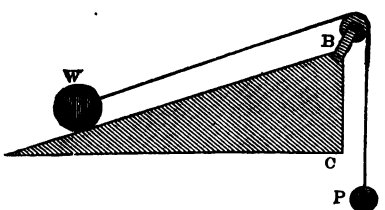


Fig. 57.

In Fig. 57, where is the power?

The power is at P.

Where is the weight?

The weight is at W.

Upon what does the power and the weight depend?

They depend upon the height and the length of the inclined plane.

When an inclined plane is ten feet long and only one foot high, how much will one pound at P balance?

One pound at P will balance ten pounds at W.

When an inclined plane ten feet long is two feet high, how much will one pound at P balance?

One pound at P will then balance only five pounds at W; because the plane is five times as long as it is high.

Where else may the power be exerted?

The power may be exerted behind the weight, as in Fig. 58.

Fig. 58.

Will any more power be needed behind the weight than before it?

No; the power required is the same in both cases.

Would it require as much power to roll barrels into a wagon as to lift them in?

No; they can be rolled into a wagon much more easily than lifted in.

Can they be taken out of the wagon any more easily on an inclined plane than without one?

Yes; they can be taken out more easily on an inclined plane.

Why are drays, used in cities, made in the form of the inclined plane?

So that barrels and hogsheads may the more easily be rolled on them.

Are our stairs in the form of the inclined plane?

Yes; they are inclined planes with steps cut in them to make the ascent easy.

Why are house-roofs made in the form of the inclined plane?

So that the water falling on them may run off readily.

What familiar example of the inclined plane may be mentioned?

The hills, all over the country, are so many inclined planes.

Of what use are the hills?

The hills carry off the waste water from the earth, so that it is kept dry enough for plants to grow.

What other example of the inclined plane may be mentioned?

The beds of the creeks and rivers are so many inclined planes down which their waters flow.

Wedge.

What is a wedge?

A *wedge* is a double inclined plane, as is represented in Fig. 59.

Fig. 59.

Of what use is the wedge?

The wedge is used in splitting logs of wood and blocks of stone.

For what other purposes is the wedge used?

The wedge is used to fasten handles in hammers, hatchets, axes, and hoes.

How is power applied to the wedge?

Power is applied to the wedge by means of sudden blows from a hammer.

What prevents the wedge from flying back after the blow?

The friction between the wedge and the other body, keeps it from flying back.

What instruments are made in the form of a wedge?

Knife-blades, hatchets, axes, razors, and cutting instruments of nearly all kinds, are in the form of the wedge.

Screw.

What is a screw?

A *screw* is another form of the inclined plane.

Fig. 60.

Where is the inclined plane on a screw?

It begins at the bottom of the screw, and winds around and around the screw until it reaches the top, as is shown in Fig. 60.

What is this inclined plane called?

It is called the thread of the screw.

How do the threads affect the screw?

When the threads are far apart, the inclined plane is steep; but it becomes less steep the nearer the threads are together.

When will the screw exert the most power?

The screw will exert the most power, when its threads are nearest together.

Of what use are screws, such as is shown in Fig. 60?

Screws are used to fasten hinges and bolts on doors and shutters, and to fasten pieces of wood together in the construction of houses, boats, wagons, and other things.

For what other purposes is the screw used?

The screw is used where much power is needed, as in the vise; where pressure is desired, as in copying letters, and in coining money; and, also, for squeezing the juice from apples, grapes, and sugar-cane.

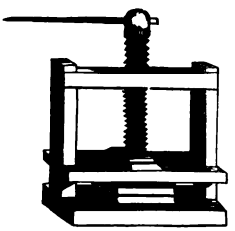


Fig. 61.

In what does a screw like that in Fig. 61 work?

It works in a nut which has threads cut on the inside, so that the threads of the screw move in them.

Where is the power applied?

The power is applied to the lever.

Can heavy bodies be raised by means of this screw?

Yes; loaded cars, and even heavy buildings, may be raised by means of a screw of this kind.

CHAPTER XI.

ELECTRICITY.

WHEN a cat's back is rubbed in the dark, what does it give off?

It gives off small sparks.

What are these small sparks called?

They are called electric sparks, or *electricity.*

If a horse be rubbed in the winter when it is dark, what will be given off from him?

Electricity will be given off from the horse.

When sealing-wax is rubbed with a silk handkerchief, or a piece of flannel, what is produced?

Electricity is produced in the sealing-wax.

What will this electricity in the sealing-wax do?

It will attract bits of paper, straw, feathers, and hairs, when it is held near them.

What other substance will act the same as the sealing-wax?

A dry glass tube will act in the same manner when rubbed.

Where is electricity found?

Electricity is found in every body, and in every thing.

How is electricity developed?

Electricity is developed by motion, by friction, and by almost every change that takes place.

Is electricity found in the air?

Yes; the air is almost constantly electrified.

With what is electricity often accompanied?

Electricity is often accompanied by heat and light.

How many kinds of electricity are there?

There are two kinds of electricity.

What are they called?

They are called *positive* and *negative* electricity.

What do these two kinds of electricity always do?

They always attract each other.

When one body contains positive and the other body negative electricity, what will the two bodies do?

They will rush together.

When both bodies are positive or both are negative, what will they do?

They will repel each other.

When a body permits electricity to pass freely through it, what is it called?

It is called a *good conductor* of electricity.

What substances are good conductors of electricity?

Metals, charcoal, water, animals, vegetables, flame, and smoke.

When a body does not permit the electricity to pass through it, what is it called?

It is called a *non-conductor* of electricity.

What substances are non-conductors of electricity?

Gutta-percha, sulphur, glass, silk, wool, hair, feathers, cotton, and paper.

What is lightning?

Lightning is electricity passing from one place to another.

When does lightning pass from one cloud to another cloud?

Whenever one cloud becomes filled with more electricity than another, the cloud having the most electricity gives off a portion to the cloud having the least electricity.

When does lightning pass from the earth to a cloud?

Whenever the earth contains more electricity than the cloud does.

When does lightning pass from a cloud to the earth?

Whenever the cloud contains more electricity than the earth does.

How near are the clouds when the lightning comes to the earth?

The clouds are seldom half a mile away when the lightning comes from them to the earth.

What noise is made by the lightning?

The lightning passes so quickly through the air, that it makes a noise called thunder.

Do we always hear the thunder when there is lightning?

No; the lightning is sometimes so far away that the thunder cannot be heard.

What bodies attract the lightning to the earth?

Tall trees, steeples, high houses, and mountains.

Does the lightning do any harm?

Yes; it does much harm by destroying trees, houses, animals, and, indeed, almost everything in its course.

What does lightning sometimes do with buildings?

It sets the buildings on fire so that they are burned.

How are buildings protected from injury by lightning?

They are protected by means of the lightning-rod, which was invented by Dr. Franklin.

Of what is the lightning-rod made?

The lightning-rod is made of some metal, usually of iron or copper, which is a good conductor of electricity.

What does the lightning-rod do when the building is struck?

The lightning-rod conducts the electricity to the earth, so that it does not injure the building.

Must the lightning-rod be higher than the building?

Yes; because the lightning is apt to strike the highest object.

Of what should the point of the rod be made?

The point should be made of silver or platinum, so that it will always remain bright.

Should the rod extend deep into the ground?

The rod should extend four or five feet beneath the surface of the earth.

Why should ashes or charcoal be put around the bottom of the rod?

Because they are good conductors and will help to conduct the lightning into the earth.

How large should the lightning-rod be?

If made of iron, the lightning-rod should be about three-fourths of an inch in diameter.

Why is glass put around the rod where it is joined to the building?

The glass is a non-conductor, and prevents the lightning from leaving the rod.

Why is it not safe to stand near a fire during a thunder-storm?

Because the fire is a good conductor, and sometimes draws the electricity into the room.

What part of the room is the safest place?

The middle of a room is thought to be the safest place.

Is a feather-bed a safe place?

Yes; because the feathers are a non-conductor, and will not attract the lightning.

Is dry air a non-conductor of electricity?

Yes; dry air is a non-conductor of electricity.

When are thunder-storms most frequent?

Thunder-storms are more frequent in summer than in winter, and more so in the afternoon than in the morning.

By what are thunder-storms usually attended?

They are usually attended by some change in the direction of the wind.

Where do thunder-storms generally prevail?

They generally prevail in the lower regions of the air, near the earth.

What is the rapidity of lightning?

The rapidity of lightning is probably not less than 250,000 miles in a second, and the flash does not exceed the millionth part of a second in duration.

Magnetism.

Of what does magnetism treat?

Magnetism treats of the property of magnets.

What is a magnet?

A *magnet* is a piece of iron ore having the power of attracting iron and steel.

How many kinds of magnets are there?

There are two kinds of magnets: natural magnets, and artificial magnets.

What other name is given to a natural magnet?

It is called a loadstone.

Where are natural magnets or loadstones found?

They are dug out of the earth, and are found most abundantly in Norway and Sweden.

What is an artificial magnet?

An artificial magnet is one made by magnetizing a bar of steel.

How may a bar of steel be magnetized?

A bar of steel, when rubbed on a natural magnet, becomes magnetized.

When the bar of steel is bent in the shape of a horse-shoe, what is it called?

It is then called a horse-shoe magnet, from its shape.

Where does a magnetic bar always point, when it is made to move easily on a pivot?

One end of it always points to the north, and the other end to the south.

What are the ends of the magnet called?

The north end is called the positive, and the south end is called the negative.

What is there curious about the magnet?

The positive end of one magnet always attracts the

negative end of every other magnet; but if the two positive or the two negative ends are brought together, they will repel each other.

Why are artificial magnets made of steel?

Because steel will remain magnetized, but iron soon loses the magnetic properties.

What is a compass?

A *compass* is an instrument containing a magnetic needle, so balanced as to move easily on a pivot.

In what direction does this needle always point?

This needle always points toward the north.

By whom is the compass used?

It is used by travellers to guide them on their journey; by surveyors to mark out the boundary lines between different properties; and by seamen to point out their way across the sea from one place to another.

Before the Mariner's Compass was invented, seamen were afraid to venture out of the sight of land, for fear of being lost on the ocean; for they then had no means of telling where they were, or in what direction to guide their vessels, so as to reach the land again.

Electro-Magnetism.

Are magnetism and electricity much alike?

Yes; they are so nearly alike that many persons think they are identical.

What is an electro-magnet?

An *electro-magnet* is a magnet obtained by means of electricity.

Of what is the magnet made?

The magnet is made of soft iron, around which are

wound a great many coils of wire, and these are covered with silk.

How is the soft iron made into a magnet?

The iron is magnetized by the passage of electricity through the wire.

Of what use is this magnet?

It is used in the electro-magnetic telegraph.

When and where was the first line of telegraph built?

The first line of telegraph was built in 1844, from Washington to Baltimore, by Professor Morse.

What is the principle of the telegraph?

At one end of the telegraph wire is an electrical battery, and at the other end is an electro-magnet. When a message is to be sent, the electricity is transmitted through the wire to the soft iron of the electro-magnet, which causes the iron to move, and this motion is conveyed to the machinery, which is needed to print the message in letters or signals, so as to be understood.

Does electricity move rapidly?

Yes; its velocity is such as to move around the earth in a quarter of a second.

What is the electrical battery called?

The electrical battery is called a *key*.

What is the electro-magnet called?

The electro-magnet is called a *receiver*.

For what are the key and receiver used?

The key is used for sending messages, and the receiver for receiving them.

What must each station have?

Each station must have both a key and a receiver, so as to send as well as receive messages.

What is the Atlantic cable?

The Atlantic cable is a telegraphic wire reaching across the Atlantic Ocean, from America to Europe.

When was the first Atlantic cable laid?

The first Atlantic cable was successfully laid in 1866, between Newfoundland and Ireland. It is eighteen hundred and sixty-four miles long, and its success is chiefly due to Cyrus W. Field.

Of what use is the Atlantic cable?

The Atlantic cable forms a telegraphic connection between Europe and America, so that news may be sent from one country to the other in a few moments of time; thus the people of the two continents, although so far apart, can communicate with each other many times in a single day.